DOCTOR OF PHILOSOPHY

Connecting the dots

A systemic approach to evaluating potential constraints to renewable electricity technology deployment to 2020 and beyond in the United Kingdom

Wood, Geoffrey Craig

Award date:
2013

Connecting the dots: A systemic approach to evaluating potential constraints to renewable electricity technology deployment to 2020 and beyond in the United Kingdom

Geoffrey Craig Wood

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the Centre for Energy Petroleum and Mineral Law and Policy (CEPMLP),

University of Dundee

September 2013

Contents

Figures and tables

List of Abbreviations

AGR	Advanced gas-cooling reactor
AONB	Areas of Outstanding Natural Beauty
BERR	Department of Business Enterprise and Regulatory Reform (defunct, now partly DECC)
BETTA	British Electricity Trading and Transmission Arrangements
BWEA	British Wind Energy Association (defunct, now Renewables UK)
CCC	Committee on Climate Change
CCGT	Combined Cycle Gas Turbine
CCL	Climate Change Levy
CCS	Carbon capture and sequestration (or carbon capture and storage)
CE	Crown Estate
CLGC	Communities and Local Government Committee
CM	Capacity mechanism
C&M	Connect and Manage
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
CPM	Carbon Price Mechanism (or CFP, Carbon Floor Price)
CPRE	Campaign to Protect Rural England
CSR	Comprehensive Spending Review
DCLG	Department for Communities and Local Government
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment Food and Rural Affairs
DfT	Department of Transport
DTI	Department of Trade and Industry (defunct, now partly DECC)
DUKES	Digest of United Kingdom Energy Statistics
EAC	Environmental Audit Committee
EC	European Community
ECCC	Energy and Climate Change Committee
EMEC	European Marine Energy Centre
EMR	Electricity Market Reform
ENSG	Electricity Networks Strategy Group
EPS	Emissions Performance Standard
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EWEA	European Wind Energy Association
FIT	Feed-in tariff
FIT CfD	Feed-in tariff contracts for difference (UK variant of FIT subsidy mechanism)
FoE	Friends of the Earth
FRED	Forum for Renewable Energy Development
GHG	Greenhouse gas emissions
HVAC	High Voltage Alternating Current

HVDC	High Voltage Direct Current
I&C	Invest and Connect
IEA	International Energy Association
IPC	Infrastructure Planning Commission (defunct)
IUSSC	Innovation Universities Science and Skills Committee
LCA	Life cycle Assessment
LCF	Levy Control Framework
LCPD	Large Combustion Plant Directive
MCZ	Marine Conservation Zones
MIPU	Major Infrastructure Planning Unit
MMO	Marine Management Organisation
MP	Marine Plans
MPA	Marine Protected Areas
MPP	Marine Planning Partnerships
MPS	Marine Policy Statement
MS	Marine Scotland
MSO	Marine Supply Obligation
NAO	National Audit Office
NETA	New Electricity Trading Arrangements (defunct, now BETTA)
NFFO	Non-Fossil Fuel Obligation
NIRO	Northern Ireland Renewables Obligation
NMP	National Marine Plan
NP	Neighbourhood Plans
NPF	National Planning Framework
NPPF	National Planning Policy Framework
NPS	National Policy Statements
NSIP	Nationally Significant Infrastructure Projects
OCGT	Open Cycle Gas Turbine
OECD	Organisation for Economic Co-operation and Development
OFGEM	Office of gas and electricity markets (regulator)
OVG	Offshore Valuation Group
OXERA	Oxford Energy Research Associates
PAN	Planning Advice Notes
PINS	Planning Inspectorate
PIU	Policy Innovation Unit
POST	Parliamentary Office of Science and Technology
PSM	Price Stabilisation Mechanism
PWR	Pressurised water reactor
RD & D	Research Design and Development
REA	Renewable Energy Association
REC	Regional Electricity Company
RED	Renewable Energy Directive (2009/28/EC)
REF	Renewable Energy Foundation
REN21	Renewable Energy Policy Network for the 21st Century
REPD	Renewable Energy Planning Database
RES-E	Electricity generated from renewable energy sources
RESTATS	Renewable Energy STATisticS Database

RET	Renewable electricity technology
RIIO	Revenues=Incentives+Innovation+Outputs
RMP	Regional Marine Plans
RO	Renewables Obligation
ROC	Renewables Obligation Certificates
rRO	Reformed Renewables Obligation
ROS	Renewables Obligation Scotland
RPS	Renewable Portfolio Standard
RSPB	Royal Society for the Protection of Birds
RRS	Regional renewable Strategies (defunct)
RSS	Regional Spatial Strategies
SAC	Special Areas of Conservation
SEA	Strategic Environmental Assessment
SMR	Scottish Marine Regions
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
SNP	Scottish National Party
SPA	Special Protected Areas
SPP	Scottish Planning Policy
SSSI	Sites of Special Scientific Interest
TAR	Transmission Access Review
UK	United Kingdom
UKERC	United Kingdom Energy Research Council
UN	United Nations
UNFCCC	United Nations Convention on Climate Change
VAR	Static Var Compensations
VSC	Voltage Source Converters

kWh	Kilowatt hour (1,000 Watt hours)
MWh	Megawatt hour (1,000 kilowatt hours)
GWh	Gigawatt hour (1,000 Megawatt hours)
TWh	Terawatt hour (1,000 Megawatt hours)

kW	Kilowatt (1,000 watts)
MW	Megawatt (1,000 kilowatts)
GW	Gigawatt (1,000 megawatts)

Acknowledgements

I would like to express my gratitude to all the staff and fellow students involved throughout my course of study in Dundee.

My supervisors, Stephen Dow and Peter Cameron (at the Centre for Energy Petroleum and Mineral Law and Policy), Andrea Ross (School of Law) and David Rodley (School of Engineering, Physics and Mathematics), who have been incredibly helpful and supportive throughout the writing of this thesis deserve a special thanks and my fullest gratitude. In particular, Stephen Dow has been a tremendous mentor over the years. Thank you for believing in me.

I am also very grateful to John Rowan, director of the Centre for Environmental Change and Human Resilience for providing me with the scholarship and support that made this thesis possible in the first place.

Finally, a project of this scale cannot be completed without the support of family and friends. I would also like to acknowledge directly the support given to be my father, particularly all the late night calls. To Ira, for your patience, support and kind understanding during these years, thank you. And to Yana, our daughter, I dedicate this to you.

Declaration

I hereby declare that I am the author of this thesis, that the work of which this thesis is a record has been done by myself, and that it has not previously been accepted for a higher degree.

Signature:……………………………………………………………..
Geoffrey Craig Wood

‘Well, in our country,’ said Alice, still panting a little, ‘you’d generally get to somewhere else – if you ran very fast for a long time, as we’ve been doing.’

‘A slow sort of country!’ said the Queen. ‘Now, here, you see it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!’

(Carroll 2000: 62)

Abstract

The UK government has committed to challenging climate change and renewable energy obligations to 2020 and beyond. The renewable electricity sector remains a key focus in meeting these targets, given the critical need to decarbonise the power sector in the longer term. This has led to an ambitious renewable electricity sectoral target of 30 percent of total electricity generation from renewable sources (RES-E) by 2020, corresponding to a deployment target of 35-40GW of installed capacity. In 2011, RES-E deployment stood at 12.3GW, resulting in the UK requiring 23-28GW of additional renewable electricity technology (RET) deployment in eight years. This requires a substantial amount of new RET capacity be adopted, the majority anticipated to come from a four large-scale (>5MW) technologies (onshore and offshore wind, biomass conversion and dedicated biomass).

However, large-scale renewable deployment has consistently under-performed against previous targets and other policy objectives. There are a number of failures that historically and currently act as constraints to RET deployment. This thesis categories those constraints as either internal or external failures. Internal failures are due to the design of the subsidy mechanism used to promote renewable deployment (type of mechanism, how it operates, revenue risk, investment (lender) risk, subsidy support levels and mechanism complexity). External failures are those constraints out-with the direct control of the mechanism (planning, network, public participation and engagement and policy risk). These constraints need to be addressed.

This thesis has carried out an evaluation of the current UK approach to large-scale RET deployment to 2020 and beyond by adopting a systemic framework approach to determine whether or not the UK will be successful in addressing the potential constraints – the internal and external failures – to deployment. The systemic approach is based on three key criteria regarding the potential constraints: a comprehensive set of constraints, analysed in-depth and taking into account the interaction of the constraints in a systemic fashion. In contrast, the government approach to dealing with these potential constraints has typically focused on failures in isolation; also government commissioned modelling and existing research does not take into account all of the internal and external failures and/or examine them in-depth. Critically, no research has analysed the systemic interactions. With this approach, this research aims to fill the gap in extant knowledge and analysis due to the absence of existing research meeting the key criteria. This thesis was carried out by a textual analysis of key policy documents and legislation that form the basis of the UK government's current approach to addressing the barriers to RET deployment. The method of inquiry utilised here is that of the qualitative research approach.

The results show that there are significant systemic interactions between the internal and external failures (internal>internal; external>external; and internal to external and vice versa). There are also a number of feedbacks, specifically between grid>planning

and public participation and engagement>planning. This creates systemic imbalances and unresolved tensions between the constraints. Importantly, the systemic interactions impact disproportionately on the key RETs, with a particular emphasis on onshore and offshore wind. By not addressing potential constraints from a systemic perspective, the current UK approach discriminates in favour of a system highly dependent on large-scale developments, of a few select RETs by a limited number of developers of a particular type (typically ex-utility, large-scale). This limits the focus on social and behavioural issues, particularly in terms of participation and engagement in ownership, decision-making and reducing the role of small-scale, independent and community group participation. In conclusion, under the current approach, decisions will be made on a separate ad-hoc basis leading to continual reform and adjustment with less clarity of where the risks lie. Increasing deployment year-by-year will only accumulate and intensify the potential constraints with limited options to address this. Effectively, government can only buy or control its way out of the constraints. In contrast, a systemic approach offers policy makers a way out of this. By providing an overview of the system and identification of systemic interactions in an early and novel way, this approach offers the opportunity for pragmatic decision-making at the systemic level leading to more predictable routes to solving problems via focused reforms, thus mitigating risks to a greater extent and redefining the system in a more optimal and resilient way. In other words, it allows government to connect the dots in addressing potential constraints to deployment.

Part I
Introduction to the dissertation

This thesis has carried out an evaluation of the current UK approach to large-scale renewable electricity technology deployment to 2020 and beyond by adopting a systemic approach framework to determine whether or not the UK will be successful in addressing the potential constraints – the internal and external failures – to deployment. This is approached by answering three specific research questions. What are the implications of the current UK approach to addressing potential constraints to renewable electricity technology deployment to 2020 and beyond? How would a UK response based on a systemic approach to renewable electricity technology deployment perform compared to the current UK Government's efforts to address potential constraints? What could the systemic approach offer to policy makers? In brief, this part sets out the reasoning and justification underlying the subject matter of the thesis and the way in which the research has been conducted. The methodological approach used within the thesis is also set out along with the justification for this particular method. Further, a review of the extant literature is undertaken in order to provide both support for and the context within which this research is positioned.

Chapter one introduces the subject area to be examined in the thesis and provides a rationale for why this topic has been chosen. In particular, this chapter highlights the critical gap in knowledge and analysis due to the absence of existing research and modelling incorporating a comprehensive and in-depth analysis of the constraints that takes into account the systemic interactions of the constraints. Building on this, this chapter questions the current UK government approach to addressing the constraints to deployment.

Chapter two presents the research methodology utilised in this thesis and sets out the reasoning behind the methodology and the discrete stages involved in the research. Specifically, the internal and external failures and the systemic approach are described.

In particular, the identification of the set of internal and external failures is explained. This chapter also determines any potential problems with the adopted methodology.

The final chapter in part one of the thesis presents a literature review of the way in which government has previously approached the barriers or constraints to large-scale renewable electricity technology deployment in the UK. As such, it draws on and develops the justification for the thesis in chapter one and sets the internal and external failures within the context of the approach adopted by the UK government to addressing constraints. This chapter incorporates a historical element, looking at both the previous subsidy mechanisms (the Non-Fossil Fuel Obligation (1990-1998) and the Renewables Obligation (2002-2009) along side wider changes to the electricity 'landscape' in general and renewable electricity policy in particular.

Chapter One

Chapter One
Introduction

1.1 The PhD in context

This thesis adopts a systemic approach to evaluating potential constraints (categorised as the internal and external failures) to large-scale renewable electricity technology deployment in the United Kingdom (UK). This thesis will provide a credible assessment of the UK Government's current approach to renewable electricity deployment with regard to the 2020 renewable electricity sectoral target and beyond.

The European Union (EU) 2009 Renewables Directive has set the UK a legally-binding target of supplying 15 percent of its energy consumption from renewable energy sources by 2020.[1] In line with the sectoral approach, the UK has set non-binding targets with regard to the contribution of the electricity, heating and cooling and transport sectors towards the renewable target. Electricity generated from renewable energy sources (RES-E) is anticipated by the UK government to provide the greatest share of the overall 15 per cent target, equating to a sectoral target of at least 30 per cent of total UK electricity generation, or 49 percent of total UK renewable generation by 2020 (Department of Energy and Climate Change [DECC], 2009).[2] The UK government

---

[1] The EU Renewable Energy Directive (RED) '2*009/28/EC on the promotion of the use of energy from renewable sources*' established a mandatory target of a 20% share of energy from renewable sources in overall Community energy consumption by 2020 (Europa, 2009). The overall Community target is translated into individual targets for each Member State with the national targets determined by the existing level of energy from renewable sources, renewable energy potential and the energy mix. This approach was adopted is in order to deliver a fair and adequate allocation taking into account current and historical variations in Member State's efforts with regard to the use of energy from renewable sources. Unlike the previous non-legally binding renewable directive '*2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal market*' (Eur-Lex, 2001), the 2009 RED target incorporates the three major sectors (electricity, heating and cooling and transport). It has been left to the Member States to determine the contribution of the various sectors to the overall target. Regarding the UK 15% target, the Directive also set interim targets: 4% for 2011/12, 5.4% for 2013/14, 7.5% for 2015/16 and 10.2% for 2017/18.

[2] In contrast, the sectoral targets for heating and cooling and transport are 12% of UK heat demand (or 30% of total renewable energy) and 10% of transport demand (or 21% of total renewable energy), respectively (DECC, 2009a).

document '*UK Renewable Energy Strategy 2009*' (DECC, 2009a) translated the 15 per cent target into 239 terawatt-hours (TWh) with corresponding sectoral targets: 114 TWh (electricity), 72 TWh (heating and cooling) and 49 TWh (transport). The electricity sectoral target corresponds to approximately 35-40 GW of renewable electricity technology deployment, compared to the 12 GW of current installed capacity with a generation output of 34 TWh in the UK as of the end of 2011 (DECC, 2009a). Critically, decarbonisation of the electricity sector is also viewed as essential with regard to transforming the UK into a low-carbon economy and to meeting the UK's climate objectives as set out in the domestic Climate Change Acts: an 80 percent reduction in greenhouse gas emissions (GHG) from 1990 levels by 2050 (for the UK overall, and at the national administrative level for Scotland) with diverging interim targets for 2020 (34 and 42 percent reductions on 1990 levels for the UK and Scotland, respectively) (Committee on Climate Change [CCC], 2010, 2011; National Archives, 2008, 2009).[3]

In addition to the UK renewables targets, the devolved national administrations have also set ambitions and targets at the overall and sectoral levels (DECC, 2012a).[4] Of the three devolved administrations, Scotland is of particular interest to the UK target. Scotland is the only nation within the UK to have adopted greenhouse gas emission reductions on a legal basis (see above). In particular, the Scottish Executive has consistently set higher targets for both renewable and RES-E generation. In 2011, the Scottish Executive declared a new target of 100 percent electricity demand

[3] There are two domestic Climate Change Acts in the UK: the Climate Change Act 2008 (encompassing the UK overall) and the Climate Change (Scotland) Act 2009. The central pillars of the legislation are the legally-binding targets for reducing GHG emissions by 2020 and 2050 and a series of carbon budgets (5-yearly and annually under the UK and Scottish legislation, respectively) which set maximum UK emissions on the trajectory for the targets. The UK Act also established the independent CCC primarily to advise the government on key matters under the Act and in monitoring and reporting on the government's progress. Climate change targets are also driven at the international level via the Kyoto Protocol which set the UK an emissions reduction target of 12.5 % below 1990 levels by 2010 (United Nations [UN], 1998) and the EU integrated energy and climate change (20-20-20) programme which set Community-level targets for reducing its overall emissions to at least 20% below 1990 levels and reducing energy demand by 20% with both targets to be achieved by 2020 (Europa, 2011).

[4] Although the EU target, and therefore the sectoral targets are set for the UK, the establishment by law of the devolved national administrations in Scotland, Wales and Northern Ireland in 1998 has resulted in the increased relevance of the contribution the administrations can play with regard to meeting the target (McEwen *et al*., 2010). The level of these targets are not designed to equate to the share of the respective devolved administrations, rather they are complementary but parallel to the UK target.

(consumption) equivalent from renewable electricity technologies (RETs) by 2020 in conjunction with a new overall renewable energy target (all sectors) of 30 percent, also for 2020 (Scottish Government, 2011a,b).[5] The 100 percent RES-E target is the most ambitious in the EU, and means that Scotland is anticipated to contribute over a third of the UK's total RES-E target, approximately 16-17 GW in terms of installed capacity (Scottish Government, 2011c). This would have significant implications for the UK overall target. Scotland already makes a substantial contribution towards renewable electricity generation in the UK with approximately half of total installed capacity and 40 percent of total UK RES-E generation output in 2010 (DECC, 2011a). Analysis has also shown that the UK requires between 6 and 11 GW of installed renewable capacity from Scotland in order to achieve the 2020 sectoral target (Electricity Networks Strategy Group [ENSG], 2009). Of all the devolved administrations, Scotland generates, consumes and exports the most electricity (including renewable electricity) and has considerable renewable energy reserves on a global scale (Offshore Valuation Group [OVG], 2010).

That the renewable and overarching climate change targets are important, particularly when viewed in the context of the UK government's commitment in moving towards a low carbon economy, is not in question. However, there are a number of additional reasons or drivers underlying the promotion of renewable energy in general and renewable electricity in particular. These include security of supply, fossil fuel dependency/depletion and benefits to the UK in terms of encouraging UK industry to develop capabilities for both domestic and export markets with resultant employment growth in a developing renewables sector. These policy objectives are clearly stated in a number of '*Energy White Papers*' during the last two decades and form the current basis for energy policy in the UK. Importantly, these objectives or energy policy goals are to be achieved through the promotion of competitive markets and result in affordable energy for the consumer (Department of Energy, 1988; Department of Trade and Industry [DTI], 1994, 2003, 2007; DECC, 2011b).

[5] As with the UK sectoral approach, the Scottish RES-E target is anticipated to contribute the greatest share of the 30% overall renewable target for 2020 (Scottish Government, 2011b).

The UK electricity sector has also been undergoing considerable change that will have significant and wide-spread implications for the future.[6] In addition to the renewable and climate change targets and the requirement to accelerate the deployment of RETs, the main promotional tool to subsidise RES-E (the Renewables Obligation, or RO) was substantially reformed in 2009. The RO places a mandated obligation on electricity suppliers to source an annually increasing amount of RES-E. The 2009 reforms introduced differentiated subsidy levels (or '*technology banding*') for the various eligible renewable technologies (Wood and Dow, 2010). In 2011, the government published the energy white paper '*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity*' as part of the on-going process of electricity market reform (EMR) (DECC, 2011b). Described as a fundamental reform of the UK electricity sector, the EMR is anticipated to be the main tool going forward to drive the decarbonisation of the electricity sector in order to meet RES-E and climate change targets whilst maintaining security of supply. Amongst other proposals, the EMR proposes to introduce a Feed-in Tariff Contract for Difference (FIT CfD) mechanism.[7] A novel variant of the existing small-scale FIT, the new mechanism is anticipated to operate along with the RO from 2014 until 2017 when the RO will be closed to new projects (vintaged). From 2017 onwards, the FIT CfD mechanism will be the main financial tool to promote large-scale RES-E generation in the UK.

When introduced in 2002, the RO was envisaged to bring on the overwhelming majority of RES-E generation in the UK required to meet the 2020 RES-E sectoral target.[8]

---

[6] As with many countries world-wide, the UK electricity (and energy) sector has experienced significant change since at least the late 1980s. The 1989 Electricity Act commenced the ongoing drive to change the electricity sector through the introduction of privatisation (the sale of state assets) and liberalisation (the introduction of competition) in order to create a market for energy (National Archives, 2011). This represented a fundamental shift in energy systems, from direct government ownership to the need to establish regulators and regulations to enforce a system of competition whilst attempting to achieve the various energy policy objectives of the government (Helm, 2008).

[7] The other EMR proposals include setting a carbon price support (CPS) to underpin the current low carbon price, an emissions performance standard (EPS) to limit the amount of greenhouse gases (GHG) from fossil fuel generation and a capacity mechanism (CM) to address security of supply concerns.

[8] Originally this meant that the 2010 sectoral target of 10% of total electricity generated from RES-E established by the EU 2001 Directive (2001/77/EC) and later the UK Government's aspirational 15% RES-E target by 2015 would be met by the RO. Although a small-scale FIT to subsidise renewable

Importantly, the proposed introduction of the new FIT CfD and the closure of the RO to new generation have resulted in a change in emphasis: the RO is now anticipated to account for around 80 TWh out of the 114 TWh sectoral target by 2017 or approximately 75 per cent of the target (DECC, 2012b). Therefore, although the EMR is anticipated to be the main tool going forward to drive the deployment of renewable electricity technologies, the RO is still anticipated to account for the majority of RES-E deployment and generation. Additional generation (the '*shortfall*') is presumed to come from the new FIT CfD in addition to the existing small-scale FIT mechanism. However, the implementation of the FIT CfD and indeed the entire EMR proposals still require to be put into legislation, and numerous concerns have been voiced regarding the demanding legislative timetable for the EMR (Energy and Climate Change Committee, 2012; Friends of the Earth [FoE], 2012; RenewableUK, 2012a). In addition, a number of issues regarding the design and implementation of the proposals regarding the FIT CfD remain vague:

> "*… with many fundamental aspects of the CfD mechanism where thinking is at an early stage with concrete proposals to be developed. Our members are nervous that at this stage there is still little detail on many of the key aspects of the CfD mechanism*" (Scottish Renewables, 2012).

Of concern, opposition to the proposals appears to be growing.[9] This means the possibility remains that the RO will be required to account for a higher share than currently envisioned if the target is to be achieved. Either way, the focus of this research on potential constraints to RES-E deployment in the UK will remain both pertinent and relevant even following the EMR (see below).

---

electricity deployment with an installed capacity of between 50 kW and 5 MW was introduced in April 2010, the target aim for this mechanism was only 2 per cent of final electricity generation in 2020 (or 8 TWh/year). In addition, the RO can also provide subsidy support to the same RETs as the small-scale FIT: onshore wind, hydro, anaerobic digestion.

[9] The House of Commons Select Committee on Energy and Climate Change recently announced in an investigation into the EMR proposals that "*… arrangements have become so complex that the proposal has now arguably become unworkable.*" (Energy and Climate Change Committee, 2012: 4). The issue of the EMR and the FIT CfD mechanism will be examined in greater detail in Chapter Seven (section 7.5).

The UK electricity sector is also facing the projected loss of around a quarter of the UK's current electricity generation capacity (the '*generation gap*'), mainly nuclear and coal-fired power stations for operational age and environmental reasons (DECC, 2011b). However, it is unlikely that all of the projected closures will take place. In particular, there are plans to extend the operational lifespan for existing nuclear plant. In addition there are numerous proposed or recently adopted changes regarding both the planning system and the electricity transmission and distribution networks (both onshore and offshore) along with additional initiatives to develop and strengthen the supply chain and facilitate access to finance for low carbon and renewable technology deployment. The impact of these changes represents a potentially profound alteration to the policy, regulatory and legislative landscape. Whether or not they achieve their objectives depends in large part on their design and implementation (Toke, 2011). Importantly, given the ambitious targets and the sheer scale of the changes proposed or already adopted for increasing the deployment of renewable energy over the next decade and beyond, consideration of the implications of meeting the target has to extend to issues beyond the traditional dominance of technological and economic approaches. Such issues include public participation and engagement and environmental issues not just associated to climate change *per se*.[10]

Importantly, the electricity or power sector has both historically and currently remains the main focus of policy and legislative effort regarding renewable energy in the UK, as

[10] As Devine-Wright (2007: 3) notes: "*Public acceptance is recognised as an important issue shaping the widespread implementation of renewable energy technologies and the achievement of energy policy targets. Furthermore, it is commonly assumed that public attitudes need to change to make more radical scenarios about the implementation of renewable energy technologies feasible.*" This argument has also been put forward by other academics and organisations (Bell *et al*., 2005; Natural Research Council, 2008). Such an observation also holds true for climate change objectives: "But i*n order for policy to be truly effective, it must win public support.*" (Environmental Audit Committee, 2007: 4). Regarding the second point, there appears to be a strong tendency to argue that the dangers of climate change mean that measures to combat it (e.g. renewable technologies) are somehow more important than other considerations. However, in a recent ruling at the Administrative Court regarding a wind farm planning proposal (Great Yarmouth, Sea Land and Power Ltd vs. Secretary of State for Communities and Local Government and Great Yarmouth Borough Council), Mrs Justice Laing stated: "*As a matter of law it is not correct to assert that the national policy promoting the issue of renewable resources… negates the local landscape policies or must be given 'primacy' over them.*" (Bailii, 2012).

evidenced by the operation of a specific delivery programme for RES-E since 1990.[11] There have been two main policy instruments to promote and subsidise renewable electricity generation technologies (RETs): the Non-Fossil Fuel Obligation (NFFO), a centralised bidding system that ran from 1990 to 1998, and the Renewables Obligation, a variant of the Renewable Portfolio Standard (RPS) – a tradable green certificate/quota system that came into effect in April 2002 (Mitchell *et al*., 2006; Wood and Dow, 2010). The under-performance of both mechanisms, however, is well documented (Butler and Neuhoff, 2008; Lauber, 2004; Lipp, 2007; Komor, 2004; Mitchell 1995; Mitchell and Connor, 2004; Ringel, 2006; Toke, 2005a, b; Toke and Lauber, 2007; Wood, 2010; Wood and Dow, 2010, 2011).

Historically the UK has consistently failed to meet RES-E targets. Only 30 percent of all accepted NFFO projects actually reached the commissioning stage over a 14-year period (Edge, 2006). For the RO, this can be seen by comparing actual RES-E generation against the annual obligation targets (as a percentage): 2.4 contra 3 (2003), 3.6 contra 4.3 (2004), 4.2 contra 4.9 (2005), 4.5 contra 5.5 (2006), 5 contra 6.7 (2007), 5.5 contra 7.9 (2008), 6.6 contra 9.1 (2009) and 6.8 contra 10.4 (2010) (Department of Business, Enterprise and Regulatory Reform [BERR], 2008; DECC, 2010a; DECC, 2011e). The 2010 target for UK renewable electricity generation established by the previous EU Renewables Directive (2001/77/EC) was 10.4 percent: the UK missed the target by approximately a third, despite two decades of effort. The current contribution of electricity generated from renewable sources stands at only 9.4 per cent in 2011 (DECC, 2012c).[12] This means that the 2010 target has still not been met. Put in perspective,

[11] In contrast to the renewable electricity sector, the Renewables Heat Incentive (RHI), the subsidy support mechanism for the heating and cooling sector was only implemented in 2011 with full implementation recently delayed by a further year until at least summer 2013. The scheme has recently been renamed as the Renewable Heat Premium Payment (RHPP) (DECC, 2011c). The Renewable Transport Fuels Obligation (RTFO) to subsidise renewable fuels commenced operation only in 2005 (Department for Transport [DfT], 2012). When looking at the sectoral contributions to UK renewable energy, out of a total renewable generation output of 54 TWh in 2010, RES-E accounted for almost half of the total renewable output. Both the heating and cooling and transport sectors contributed approximately 25% each (DECC, 2011d).

[12] This can also be seen when comparing UK RES-E performance with other EU countries efforts. In 2010, the EU (27 countries) average was 20%. At around 6.7%, RES-E as a percentage of total electricity consumption equated to the fourth lowest amount, only above Luxembourg (3.1%), Cyprus (0.7%) and Malta (0%). In contrast, the majority of EU states performed significantly better than the UK: Germany

with only nine years until the 2020 target deadline, the UK is required to more than triple renewable electricity generation output.

As a result, the NFFO and RO have not delivered deployment at expected levels and energy policy objectives have either not been met (developing export and domestic market capabilities) or non-optimally (security of supply, fossil fuel dependency/depletion and environmental goals) (Wood and Dow, 2011). This is significant given recent analysis of terrestrial and marine renewable energy resource availability in the UK. The 2010 Offshore Valuation Group report '*The Offshore Valuation: A valuation of the UK's offshore renewable energy resource*' determined that potential marine resource reserves alone could provide over 2,100 TWh per year in renewable electricity generation output. In comparison, total electricity consumption in 2010 was 336 TWh (DECC, 2011a).

There is also the issue of the relative contribution of the different technologies to the 2020 RES-E sectoral target and beyond. Although hydro power previously accounted for virtually all renewable installed capacity (measured in Mega-watts electricity, or MW) up to 2004, a legacy of the past construction of large-scale reservoir dams after World War II, onshore wind in particular and wind power in general have played the major role in driving new RET deployment capacity in the UK (DECC, 2012c). Over the period 2001-2010, onshore wind consistently exhibited the largest annual installed capacity and cumulative capacity growth since 2005 of any individual renewable electricity technology (BERR, 2008; DECC, 2011e). At the technology '*family*' level[13], onshore and offshore wind accounted for 53 percent (+6,488 MW) out of a total installed capacity of +12,310 MW in 2011 with onshore alone accounting for 72 percent of total wind capacity. Overall, wind power capacity is over twice that of bioenergy and waste (26

(17%), Denmark (33%), Ireland (13%), Greece (17%), Spain (33%), France (15%), Italy (22%), and Portugal (50%). For a more complete dataset, see Eurostat (2012).

[13] A RET 'family' includes similar or associated technologies: for example, wind incorporates onshore, offshore and micro-wind. Offshore wind could be further categorised into fixed offshore and floating offshore. There are six major 'families' of RETs incorporating various sub-categories. For further explanation, see chapter two (section 2.5).

percent, or 3,167 MW) and almost four times as much as total hydro (1,676 MW, or 14 percent). In terms of generation output (measured in Giga-watt hours, or GWh), however, bioenergy and waste has dominated output until 2011 when total wind generation surpassed all other RETs: 15,498 GWh (or 45 percent out of a total RES-E generation output of 34,410 GWh) compared to 12,973 GWh (37 percent) for bioenergy and waste and 5,686 GWh (17 percent) for hydro power. Again, in absolute terms, annual generation output from wind has increased around fifteen times during the period 2001-11, whereas bioenergy and waste has increased around 3 times. Hydro power has showed negligible increases overall due to insignificant growth in installed capacity.

The UK Government has effectively singled out a number of RETs anticipated to contribute the majority of deployment to 2020 and beyond. The '*UK Renewable Energy Roadmap – July 2011*' (DECC, 2011a: 13) concluded on the basis of an analysis of potential deployment to 2020 that four key renewable electricity technologies could account for the majority of deployment and generation output: onshore wind (from 4.6 GW/10.3 TWh in 2011 to 13 GW/34 TWh by 2020), offshore wind (from 1.8 GW/5.1 TWh in 2011 to 18 GW/45.5 TWh) and biomass electricity (from 2.5 GW/12.9 TWh to 6 GW/39 TWh by 2020). The majority of growth in biomass electricity is anticipated to be met from biomass conversion and dedicated biomass.[14] Based on the UK Government's analysis, then, onshore wind would be required to increase by +8.4 GW, offshore wind by +16.2 GW and biomass electricity by 3.5 GW. Critically, these figures reveal the predominance of UK deployment on these four renewable technologies, in particular wind power. In contrast, independently commissioned analysis on potential renewable deployment rates by AEA (2010: ('*Analysis of Renewables Growth to 2020 – March 2010*') and ARUP (2011: '*Review of the generation costs and deployment potential of renewable*

[14] These figures are modelled 'estimates' of central deployment ranges and do not represent technology specific targets of the level of UK Government ambition (DECC, 2011a). The full range for each of the four technologies is: onshore wind (10-19 GW, or 23-45 TWh), offshore wind (11-26 GW, or 33-58 TWh). Although the UK Renewable Energy Roadmap did not break down statistics for the various biomass electricity RETs, analysis by AEA (2010) for the Roadmap document did: dedicated biomass (central range 2.3 GW or 16.5 TWh, full range 1.8-4.1 GW or 12.5-28.8 TWh) and biomass conversion (central range 1.1 GW or 8 TWh, full range 0-2.6 GW or 0-18.4 TWh).

electricity technologies in the UK – October 2011') concluded that all other technologies were not expected to contribute significantly to the 2020 sectoral target. These RETs include: marine renewables (wave, tidal stream), geothermal, biomass co-firing, waste (sewage gas, landfill gas, energy from waste, anaerobic digestion) and solar PV.[15]

It is only in the last year (2010-11) that the dominant trends appear to change significantly (DECC, 2012c, d). Over the period 2001-2010, in both relative and absolute terms, wind power dominated annual installed capacity growth, accounting for around 80 percent of annual new RES-E capacity growth on average. This is consistent with the anticipation that wind power, both onshore and offshore, will contribute the vast majority to the UK RES-E sectoral target. However, in 2010-11, the share of total wind dropped from 81 percent in the previous year to just 37 percent, the first time that wind power has experienced such a drop in annual growth in installed capacity. Although the share of onshore wind to annual installed capacity had been dropping in recent years due to a corresponding growth in the share of offshore wind, the primary reason is due to highly significant deployment growth in two RETs that had displayed very little growth overall: solar photovoltaic increased from 77 to 976 MW (+899 MW) and plant biomass from 330 to 1,159 MW (+829 MW), accounting for 30 and 27 percent of total installed capacity growth in the same period, respectively. In comparison, onshore and offshore wind grew by +614 and +497 MW, respectively. Marine (wave, tidal) and geothermal currently make no impact on deployment levels.

The scale of the target is clear.[16] But why has large-scale renewable electricity deployment, and hence generation output, consistently under-performed against the set targets so far? Critically, what are the implications of this going forward for the 2020

[15] Marine renewable and geothermal technologies are at too early a stage to contribute significantly to deployment until post-2020. With the exception of anaerobic digestion, biomass waste RETs have limited opportunity to continue increasing deployment. It should be pointed out that none of these reports anticipated the significant growth in solar PV (see in text for further examination). See AEA (2010) and ARUP (2011) for a more detailed explanation.

[16] Indeed, the government has recognised this, as can be seen by the use of terminology in various official documents to describe the 2020 sectoral goal: '*radical*', '*very ambitious*' (DECC, 2009: 8), '*challenging*' (DECC, 2011f: 9) and '*a huge challenge*' (DECC, 2011b: 27). The Scottish Executive describes the 100% renewable electricity target as "*a major challenge*" (Scottish Government, 2012a: 29).

sectoral target and beyond? There are a number of barriers or failures that act as constraints to renewable deployment in the UK. In order to evaluate the potential constraints to the necessary levels of deployment required to achieve the 30 percent renewable electricity generation target, this thesis draws on the '*internal and external failures*' approach developed in Wood and Dow (2010) and further elaborated in Wood (2010) and Wood and Dow (2011). This approach categorises those constraints as either an internal or external failure. Internal (or structural) failures are barriers due to the design of the financial (subsidy) mechanism used to promote renewable deployment. This category includes the type of promotional mechanism and how it operates, for example, what impact does the mechanism have on price/revenue and investment (lender) risk, mechanism operational lifetime (subsidy programme and/or subsidy duration), subsidy levels and mechanism complexity. External failures are those barriers out-with the direct control of the mechanism, including planning, electricity network, public participation and engagement and policy risk and uncertainty.[17]

It is these potential constraints to the actual real-world deployment of those large-scale electricity supply technologies required to generate renewable electricity that are the primary focus of this thesis. In order to provide a valid evaluation of the potential constraints to deployment, and to answer the question of whether or not the current UK approach to addressing these constraints will facilitate meeting the sectoral target, there are a number of criteria that must be met. This is critical to ensure that any analysis is rigorous, credible and transparent. Firstly, the set of constraints included in the internal and external failures approach needs to be comprehensive: the internal and external failures have to at least capture the significant constraints that affect such deployment. Secondly, the constraints should be examined in sufficient depth; it is not enough to mention potential constraints without proper investigation and analysis. Thirdly, individual constraints can interact with each other in a way(s) that could aggravate the impact of the potential constraint(s) in a system-wide or systemic way. Therefore the systemic interaction of the constraints must be analysed. As Baker *et al* (2011: 5) point out:

[17] The internal and external failures approach will be looked at in more detail in Chapter Two.

> "*In a perfect, first-best world, it should be possible to address and optimise individual elements of energy policy in isolation, with confidence that the overall policy outcome would also be optimised. However, the world is not perfect and measures designed to deliver desired outcomes in particular policy areas may lead to distortions in other areas, with a consequent need for compensating action.*"

In other words, efforts to address a particular constraint without taking into account the systemic interaction of that constraint on other internal and external failures could lead to the situation where not only is the problem shifted from one failure to another, or between the internal and external failures and vice versa, but also where efforts to address a barrier aggravates other barriers to the extent that they result in lower deployment levels than would otherwise be achieved.

1.2 Justification for the PhD

This thesis, then, will adopt a systemic framework to evaluating potential constraints (the internal and external failures) to large-scale renewable electricity deployment. Research has been conducted in recognition of the range of potential constraints to renewable deployment. This includes government commissioned modelling, academic and non-academic research and previous research carried out by the author of this thesis.

1.2.1 Government commissioned modelling

In light of the target, since 2008 the UK government has commissioned various modelling studies to assess the UK's ability in delivering a major expansion of renewable electricity generation consistent with the sectoral target of the overall EU renewable energy target for 2020. In particular, there are two major analyses of relevance to this thesis regarding whether or not the UK will meet the sectoral target: '*Electricity Market Reform: Analysis of policy options*' (Redpoint Energy in association with Trilemma UK, 2010) and '*Analysis of Renewables Growth to 2020*' (AEA Technology plc [AEA], 2010).[18] These studies are of further relevance to this research because they

[18] The Redpoint and Trilemma UK (2010) study is actually the third in a series of analyses led by Redpoint Energy working with various organisations. The previous studies are: '*Implementation of EU 2020 Renewable Target in the UK Electricity Sector: Renewable Support Schemes*' (Redpoint Energy, Trilemma

have contributed directly into major UK government renewable energy initiatives, from the development of the 2009 UK renewable energy strategy to the current EMR process. As such their analyses have credible influence over policy decisions.[19]

A critical question with regard to these studies is to what extent they address the issue of potential constraints to renewable deployment. The Redpoint and Trilemma UK (2010) study set out to demonstrate that reforming to the Great Britain electricity market is required in order to replace the expected closure of around 20 percent of the UK's electricity generation capacity and achieve decarbonisation of the electricity sector and meet domestic climate change targets while maintaining secure and affordable supplies for consumers. This was approached by modelling a business as usual evolution of the generation market under current policies (primarily the Renewables Obligation) and comparing this with modelling analysis of the proposals put forward under the electricity market reform white paper. In other words, the focus of the analysis is on the internal failures in general and the design/operation of the subsidy mechanism in particular. Despite such a focus, however, not one of the six scenarios modelled incorporated a realistic analysis of RES-E deployment. Supposedly "*a 'business as usual' evolution of the GB generation market under current policies*" (Redpoint and Trilemma, 2010: 5), the baseline analysis assumed that the RES-E target would be met:

> "*We have adjusted future ROC bands upwards in order to deliver 29% generation from all renewables by 2020, a figure consistent with DECC's Renewable Energy Strategy to meet the total 2020 renewables target.*" (Redpoint and Trilemma, 2010: 22).

UK and the Electricity Policy Research Group [EPRG], 2008), '*Implementation of the EU 2020 Renewable Target in the UK Electricity Sector: RO Reform*' (Redpoint Energy and Trilemma UK, 2009). All three studies examine various options with regard to their suitability in delivering the major expansion of RES-E required by the 2020 target. Although the focus here will be on the most recent study (2010), where relevant the 2008 and 2009 analyses will also be examined.

[19] The analysis and findings of the Redpoint Energy and Trilemma UK (2009) study were used directly in support of the 2009 'UK Renewable Energy Strategy' (DECC, 2009: 38) document: "*…to understand how this target* [the UK's 15% renewable energy target by 2020] *might be delivered… we have modelled different 'scenarios' using updated analysis about the costs, carbon savings and the potential for deploying these renewable technologies* [from Redpoint Energy and Trilemma UK (2009)]." Redpoint Energy (in association with Trilemma UK) were also commissioned by DECC to conduct the analysis in support of the EMR proposals (DECC, 2010b; Redpoint Energy, 2010). The AEA (2010) study fed into the analysis supporting the 2011 '*UK Renewable Energy Roadmap*' (DECC, 2011f).

The same fundamental assumption was used for the other five modelled scenarios analysing the proposals put forward under the EMR.

Crucially, as a result, this analysis did not examine any external failures:

> "*The analysis is focused on the different financial incentives under each of the EMR options and does not consider other factors that may affect the rate of new generation investment, such as resource potential, planning, connections and supply chain constraints. One key assumption, for example, is that these issues will be sufficiently addressed such that the 2020 renewables target could be met with the right level of financial support, whether under the Baseline or any of the proposed reform packages.*" (Redpoint and Trilemma UK (2010: 19).[20]

This is significant given that such constraints "[Can] *have a major impact on the realisation of policy objectives.*" (Platchkov *et al.*, 2011: 12). Such an omission is surprising. The Redpoint and Trilemma UK (2010) report explicitly states that reaching the sectoral RES-E target is dependent on the assumption that the external failures are overcome (in addition to there being a sufficient level of projects suitable for development). The Redpoint and Trilemma UK (2009: 4) report goes further:

> "*Our base modelling assumes that significant progress is made in [addressing planning issues, grid expansion and connection and supply chain growth] to enable a much higher deployment rate than is currently the case [under existing policies such as the RO]. Were this not to materialise, it is unlikely that renewable generation would exceed around 17% by 2020.*"[21]

[20] The absence of any analysis of the external factors and the held assumptions is a common one for the three Redpoint led studies. The Redpoint Energy, Trilemma UK and EPRG (2008: 4) study states: "*Adopting an effective financial support scheme to stimulate the levels of investment required to reach the target generation from renewable sources within just a decade will form one component of the Government's strategy. However, at least as important will be policies that address current constraints in planning and renewables supply chain, and that promote the efficient expansion of the grid... None of these additional policy considerations were within the scope of this study.*" The Redpoint Energy and Trilemma UK (2009: 4) study also makes the same point: "*There is a plethora of other considerations that will have a large bearing for the UK in meeting its target, including planning issues, grid expansion and connection, and supply chain growth. Our base modelling assumes that sufficient progress is made in these areas to enable a much higher deployment rate that is currently the case.* "

[21] The Redpoint Energy, Trilemma UK and the EPRG (2008: 5) study also repeats this warning, stating that "*... failings in any of these areas could jeopardise the achievement of the targets, and could have other consequences such as unnecessarily increasing the costs to consumers.*"

Another critique of the Redpoint led scenarios is the assumption of accelerated progress over the next decade towards meeting the sectoral target. This reveals a lack of consideration of issues such as the increased aggravation of potential constraints over time (including the depletion of the best wind resource sites for onshore wind, policy uncertainty, investment hiatus or fuel-stock sustainability issues for biomass) and does not take into account the potential impact of systemic failures on deployment.

In contrast, the AEA (2010) report for DECC explicitly set out to investigate a comprehensive set of potential constraints to RES-E deployment regarding the 2020 sectoral target. Primarily the report set out to assess industry's view of the likely level of deployment by 2020, based on the measures presented in the 2009 Renewable Energy Strategy. This would be built onto the current state of deployment (taken from 2005 to 2009) and would take into account the amount of capacity currently in the project development pipeline, defined as encompassing initial project planning, the planning application process and the subsequent period during which projects are financed and built prior to commencing energy production. As with the Redpoint led reports, in general the constraints categorised in the AEA report conform directly to those utilised in the internal and external failures approach. These include market incentives (subsidy level), planning, electricity network, supply chain, policy risk/uncertainty, institutional barriers, motivating investors to act and other constraints (public engagement and acceptability).[22] The AEA study examines the technologies on an individual basis. Overall, the report concluded that out of three scenarios (low or 'pessimistic', central and high or 'optimistic'), only the low scenario would miss the sectoral target of 114 TWh per year: low (86.2 TWh), central (135.7 TWh) and high (185.3 TWh). In other words, although the other scenarios would comfortably meet the target, the low scenario would achieve only around 75 percent of the target. The report concludes that the target can be met but that there is no room for complacency.

[22] The institutional barriers and motivating investors to act categories in the AEA study are combined within other categories within the internal and external failures approach (see chapter two).

However, there are a number of points of concern. The report attempted to gauge the likely level of deployment that could be stimulated based on the measures already in place or announced in the 2009 '*Renewable Energy Strategy*' document. Therefore, the data cut-off point was from 2009, before the EMR/RO transition and vintage proposals and the substantial changes proposed or adopted since. The report was also prepared over one month (March 2010), an apparent condition of the government commission. As AEA (2010: 2) note: "*We must stress that in the very limited time available it has only been possible to provide an initial view of the bottom-up assessment of the future deployment potential.*" With regard to the primary aim of the report, to gauge industries view of the likely impact of the potential constraints on RES-E deployment to 2020, the report states (AEA, 2010: 9): "*This is the area that is possibly the most subjective and therefore care needs to be exercised when interpreting the results.*" Although this was a foreseeable concern given the approach adopted (and the consultation from the UK Government), the limitations are clear. It is based solely on the view of industry. However, no information is provided in the report regarding which companies or organisations are included within the term 'industry'.

In addition, although the list of potential constraints examined in the study is comprehensive, the analysis (level of depth or detail) of the constraints varies from constraint to constraint, technology to technology and there are significant assumptions incorporated into the report. This is of particular concern when the three renewable energy technologies expected in the report to contribute the majority of RES-E deployment are examined. Onshore wind, offshore wind and biomass electricity are projected to account for over 80 percent of total RES-E generation by 2020 under all three scenarios.[23] Whilst the analysis for offshore wind potential constraints is sufficiently robust with no major assumptions, in contrast the level of detail regarding constraints for onshore wind in particular and biomass electricity are sparse and based

[23] Low estimate scenario: onshore wind (23 TWh out of a total of 86 TWh, or 27%), offshore wind (30TWh/86TWh, or 35%), biomass electricity (19/86 TWh, or 22%) would contribute 84% of total RES-E generation. Central estimate: onshore wind (35/135 TWh, or 26%), offshore wind (57/135 TWh, or 42%, biomass electricity (27/135 TWh, or 20%) would contribute 88% of total RES-E generation. High estimate scenario: onshore wind (45/185 TWh, or 24%), offshore wind (81/185 TWh, or 44%), biomass electricity (37/185 TWh, or 20%) would contribute 88% of total RES-E generation (AEA, 2010).

on unsubstantiated assumptions.[24] For example, the report states that industry is '*reasonably optimistic*' that between 8-14 GW of onshore wind installed capacity will be achieved if there is adequate subsidy (financial) support, that planning is no more difficult than at present, capital becomes more available and that the majority constraints are addressed (including grid and aviation). In short, the report merely assumes that all the major constraints will be resolved: it is assumed that planning issues will be somehow addressed by the Infrastructure Planning Commission (IPC) or an alternative body (the IPC will now be replaced), that the prospect of new grid connections will occur in a timely and appropriate fashion and that no changes in subsidy will occur between 2009 and 2020. The report highlights the importance of these assumptions, particularly for onshore wind and biomass electricity:

> "*The main concerns are that if any of the policies or actions put in place change or fail to address the constraints as expected, this level of deployment* [up to 8-14 GW in the Central estimate range] *may not be possible.*" (AEA, 2010: 15).

In other words, according to this report, failure to address the potential constraints could result in the inability of the UK to achieve the RES-E sectoral target. Interestingly, in terms of deployment rates, onshore wind is estimated to increase deployment anywhere from 600 MW per year (low estimate) to 2,000 MW per year (upper estimate). Compared to average annual deployment rates, however, the AEA estimates appear quite high even in comparison to the low estimate rate: between 2003 and 2011, onshore wind has averaged annual growth of approximately 440 MW, with the highest single year increase of 737 MW in 2007-08 (DECC, 2011g).[25] This means that the UK has to increase average annual capacity increases by around 50 percent in order to just meet the low estimate scenario.

---

[24] For biomass electricity, it is assumed that the average planning success rate (2009-20) will be perfect, at 100 percent for projects greater than 50 MW installed capacity.

[25] The actual data from DECC (2011g; DECC, 2012c) is: 678.9 MW (2003), 809 MW (2004), 1,351 MW (2005), 1,651 MW (2006), 2,083 MW (2007), 2,820 MW (2008), 3,483 MW (2009), 4,036 MW (2010) and 4,632 MW (2011).

1.2.2 Academic and non-academic research

There also exists a substantial body of academic and non-academic literature from the early 1990s onwards highlighting the importance of the potential constraints omitted and assumed to be resolved from both the Redpoint led and AEA studies[26] With regard to academic work on the constraints to large-scale renewable electricity technology deployment in the UK, even a cursory examination of the extant literature reveals an extensive body of work spanning at least the last two decades or so. This research covers both the Non-Fossil Fuel Obligation (NFFO) and the Renewables Obligation (RO) mechanisms. Typically, however, such research and analysis focuses on only a select few barriers involving either internal or external failures or a combination of both. Further, such research focuses in detail on a particular RET or more generally on a number of technologies. The objective, however, is normally specific, such as investigating the impact of the type and design of the RES-E subsidy mechanism, the planning system or policy risk on RES-E deployment levels, or carrying out a comparison of different subsidy mechanisms adopted in various countries (for example, the Renewables Obligation contra Feed-in Tariff mechanisms). Examples of such work include Connor (2003), Foxon *et al*., (2005), Komor (2004), Lauber (2004), Lipp (2007), Mitchell (1995, 1998), Mitchell and Connor (2004) and Mitchell *et al.,* (2006).

Regarding the use of a systemic approach to analysing potential constraints to RES-E deployment in the UK, there appears to be little specific work overall in this area. With a particular regard for large-scale RET deployment, such research focuses on onshore wind power in particular, and specifically in relation to the design of the subsidy mechanism, renewable energy technological maturity level and the planning system. For example, in an analysis of the RO mechanism, Woodman and Mitchell (2011: 3917) touch briefly but lucidly on the systemic approach:

[26] [26] Briefly put, academic work is peer-reviewed. Non-academic work is defined here as non-peer reviewed. In addition, although it can be from a variety of sources (Government, official bodies, organisations, committees, non-governmental organisations and any other such bodies) it can also be produced by academics. No assumptions are held in this thesis regarding the quality of academic and non-academic research: all research utilised here will be checked for internal consistency, credibility and transparency.

> "*It would be wrong to suggest that the design of the RO was the sole reasons for the UK's slow deployment of renewable* [electricity] *generation. Two other factors – the planning regime and access to the* [electricity] *network – also play an important role… While these two areas are clearly significant barriers to the rapid deployment of renewables, we would argue that they are in part a function of the design of the RO, rather than separate issues. The risks inherent in the mechanism and the consequent need to ensure a high rate of return on an investment mean that developers have tended to concentrate on sites with the highest available resources, rather than trying to develop projects in areas which may be less optimal but might also be more feasible.*"

Focusing primarily on the requirements for changing the overall UK energy system from a high to low carbon basis, Woodman (2008: 10, 56) highlights the need for a holistic approach in addressing the barriers to renewable energy:

> "*Achieving a deliberate change of* [energy] *system… will require determined action from policy makers… in a much more holistic way than has so far been the case…* [p.56] *The need is therefore for a more integrated, holistic policy approach… Dealing separately with the various obstacles to the increased take up of renewables, and other low-carbon technologies, is to an extent artificial, in that such obstacles tend to be interrelated. In other words, their extent and impact are to a degree influenced by other system components.*"

Although focusing heavily on meso-scale and not large-scale renewable technology deployment, Watson *et al*., (2010) also highlight the lack of attention in the UK government approach to addressing the systemic barriers to deployment.[27]

As with the modelling reports (see above), however, overall none of the academic and non-academic research considered here sufficiently fulfilled all three criteria deemed necessary in order to provide a rigorous and credible evaluation of the overall UK approach: comprehensive data set, in-depth examination of the potential constraints and the systemic interaction of the constraints.[28]

---

[27] Meso-scale deployment is defined as "… *between the end user and central provision*" (Watson *et al*., 2010: 12).

[28] It is important to point out that such omissions should not be construed as either criticism or failings of the academic work: it was not the aim of such research to fulfil the three criteria established in this research thesis, other objectives were set out. The same follows for the modelling reports (Redpoint, AEA). These reports carried out the consultation brief as set out under instructions from the government.

1.2.3 Previous research carried out by the author of this thesis

It is also relevant to clearly set out previous research carried out by the author of this thesis. This is in-order to establish what research was undertaken and specifically to point out the limitations and differences between previous academic work and the research utilised in this thesis by the author.

Wood (2010) and Wood and Dow (2010, 2011) have analysed the internal and external failures of the NFFO, the RO and the reformed (post-2009) RO in the UK and Scotland. These papers analysed a number of issues, including a re-examination of UK renewable energy policy from 1990 to 2010 to determine if the government had learnt from previous experience in reforming the RO and to assess the likely impact of reforming the RO in the UK and Scotland with regard to the 2020 RES-E sectoral target. These papers found that the failure to address such potential constraints despite a change of subsidy mechanism increased the risks, costs and uncertainty to renewable investors and generators and seriously limited the level of deployment that could otherwise have been attained, resulting in significant doubt over whether the objectives will be met and the requirement of future policy, regulatory and legislative changes. In summary,

> "*Although the reformed RO will increase subsidy levels and has attempted to address the main external failures (planning, grid), by not addressing the issue of high price/financial risk and increasing overall mechanism complexity… the main internal failures have still not fully been resolved. In addition, the success of the mechanism will again be heavily dependent on a select few technologies and whether or not the measures to combat the external failures are successful.*" (Wood and Dow, 2011: 2242).

Importantly, Wood and Dow (2010, 2011) found that one positive and significant step was reforming both the planning system and electricity network more-or-less sequentially with the 2009 reform. This provided a '*renewables package*' in the sense that it attempted to address the barriers and challenges to both the internal and external failures. This was in contrast to previous adjustments to single instances of

---

The research methodology and analytical framework (see chapter two) will clarify the approach to the extant literature review and choice of academic (and non-academic work) used in this research.

failure. However, as noted above, since 2010 there have been a plethora of changes resulting in a potentially profound alteration to the policy, regulatory and legislative landscape. The proposed subsidy mechanism change from the RO to the CfD FIT, including a transition period with both mechanisms operating in parallel (2014-2017) and the closure of the RO to new generation (2017) along with major reforms to both the planning regime and the electricity network result in changes (proposed or adopted) to all the internal and external failures. With hindsight, it can be concluded from Wood and Dow (2010, 2011) that a new approach by Government to addressing potential constraints to RES-E deployment would be required. Research into the precise relationship between the internal and external failures using the three criteria (comprehensive, in-depth and systemic) was essential in the development of renewable policy. Without this approach occurring, it was likely that additional reforms and adjustments to the policy, legislative and regulatory landscape would continually be required to address the failures.

It is also important to clarify the limitations and differences regarding the previous research carried out by Wood (either singly or with Dow). Previous academic research did not set out to meet the three criteria: not all of the internal and external failures were evaluated, and those failures examined were not analysed to the same level of depth. Of particular relevance, none of the previous research adopted the systemic approach utilised in this thesis.

1.2.4 Justification for the PhD

Thus, no research has taken into account all three of the criteria required to produce a credible evaluation of the potential constraints on RES-E deployment in order to answer the question of whether or not the UK will achieve the sectoral target by 2020. In particular, the studies commissioned by DECC (Redpoint, AEA) were based on the assumption that the issue of potential constraints, internal and external, would be resolved (or required to be resolved) in order that the target would be achieved. This is a critical gap with respect to both the methodologies used and the extant research currently available given the demanding target, in terms of the size of the challenge (9 percent contra 30-35 percent) and the limited time in which to achieve it (less than 10 years). This thesis, by adopting the particular approach taken here, is unique in that it utilises a holistic or systemic evaluation of potential constraints on renewable electricity deployment, based as it is on a detailed and expanded data-set.

The critique levelled at the modelling reports should not be taken to imply that the UK Government is not making any attempt to address the issue of the potential constraints to deployment. As stated previously, the UK has a relatively long-standing history of supporting RES-E and there are numerous changes proposed or recently adopted by the Government with the aim to achieve the sectoral target. This thesis seeks to assess the current UK approach to RES-E deployment by carrying out an evaluation of the potential constraints to large-scale renewable electricity technologies. Specifically, this research questions the way in which the UK approach attempts to deal with the barriers to deployment. As such, this work has implications not only with regard to answering the question of whether or not the current UK approach to addressing these constraints will facilitate meeting the target but also concerning the future operation of the proposed FIT CfD mechanism.

Any investigation of whether or not the UK approach to renewable electricity deployment will meet the RES-E sectoral target will also undoubtedly touch on current discussions of wider issues facing not only renewable electricity but renewable energy and energy policy in general. As Kern and Mitchell (2010: 5) put it: "*An important government goal in the context of making the energy system more sustainable is to deploy renewable energy technologies.*" Taking this further, a sustainable energy system will form a core component in any transition to a sustainable economy. Such issues include: how much energy is actually required? What about energy efficiency/conservation and demand reduction? Should the energy system be decentralised versus centralised; small-scale versus large-scale generation? What about the role of the public in terms of participation, use and control of energy resources? Should energy be treated as just another commodity? These are complex issues that will necessarily involve behavioural, social, economic, regulatory, legislative, political and technical change. As such, these questions point towards a central issue that policy makers are increasingly required to at least acknowledge: What are the fundamental objectives underlying a move towards a sustainable energy system? In other words, what type of system is ultimately envisaged and how will it be attained?[29] These are pertinent concerns given that the UK renewable energy system is overwhelmingly dominated by large companies, wind power and increasingly larger, industrial-scale, centralised renewable electricity power stations.[30]

1.3 Research objective

The objective of this research is primarily to develop an enhanced understanding of the potential constraints to large-scale renewable electricity generation technologies in the UK. Specifically, this research adopts a systemic framework approach to evaluating an in-depth and comprehensive set of potential constraints – the internal and external failures – in order to carry out a detailed qualitative-based assessment of the UK approach to large-scale RES-E deployment in light of the 2020 sectoral target.[31] An awareness of the limitations of the current regime is an essential precursor to more timely and effective action. With regard to the UK approach, a well designed and coherently coordinated approach to RES-E deployment could spur a cycle of more

---

[29] Although it is not the function of this research to answer these questions, it is important to recognise that this is the wider context in which energy policy currently sits.

[30] The six vertically-integrated companies collectively known as the '*Big Six*' supply over 99% of the electricity sold in Great Britain and own more than two-thirds of the total power stations. Four of these companies are at least partially state-owned: EDF Energy (France), E.ON (Germany), RWE npower (Germany) and Scottish Power (owned by Iberdrola, Spain). The two remaining companies are Scottish and Southern Energy and Centrica (owner of British Gas) (Friends of the Earth, 2011; Office of Gas and Electricity Markets [OFGEM, 2011a). Each of the 'Big 6' companies is essentially a group of companies with interests in generation, supply and often transmission/distribution (this is the meaning of vertically-reintegrated). Regarding the size of RES-E plant, although 58% of current wind deployment (both onshore and offshore) consists of wind farms with an installed capacity of less than 50 MW, the planned growth in offshore wind would see farms in excess of 1 GW installed capacity. Some examples include: London Array (1 GW), Argyll Array (1.8 GW), East Anglia (7.2 GW), and Dogger Bank (up to 9 GW, covering around 6,500 km² or an area equivalent to Yorkshire) (RenewableUK, 2012b). Indeed, the Crown Estates has five offshore leasing rounds accounting for a potential of over 40 GW offshore wind installed capacity (Crown Estates, 2012).

[31] The aim of this research is not to produce a quantitative assessment of the exact deployment rate in the UK with regard to the 2020 RES-E sectoral target, as has been carried out in various modelling reports. Rather, the underlying objective is to carry out a textual analysis of key policy documents and legislation in order to carry out an evaluation of potential constraints on renewable electricity technologies with regard to determining whether or not the UK approach to the sectoral target will be met or not.

effective government policies, business investments and public engagement that has a more reasonable chance of achieving the target.

1.4 The Research Questions

In attempting to determine whether or not the UK approach will be successful in addressing and resolving the potential constraints to RES-E deployment, the research questions will be used to evaluate the policy implications of the potential constraints (the internal and external failures) for different renewable electricity technologies and the systemic consequences with regard to the UK approach in terms of the target. It should be noted that the method of inquiry utilised in this research is that of the qualitative research approach.

Following from the considerations outlined above, this will be approached by answering three specific research questions:

> *What are the implications of the current UK approach to addressing potential constraints to RES-E deployment to 2020 and beyond?*
>
> *How would a UK response based on a systemic approach to renewable electricity technology deployment perform compared to the current UK Government's efforts to address potential constraints?*
>
> *What could the systemic approach offer to policy makers?*

1.5 Scope of the thesis

The scope of this thesis concentrates on five particular areas. First, this thesis is focused on the United Kingdom of Great Britain and Northern Ireland. The UK consists of four countries: England, Northern Ireland, Scotland and Wales. The latter three of these are devolved administrations, each with varying powers. This has particular implications regarding energy policy in general and renewable energy in particular, along with associated areas including planning law. In addition, given the relative importance of Scotland with regard to overall deployment levels and contribution to meeting the sectoral target, this thesis also looks specifically at Scotland where relevant. Unless explicitly stated otherwise, this thesis will discuss the situation in the UK overall. The primary reason for this is that the EU 2009 Renewables Directive (2009/28/EC) is set at the national level, meaning the UK. As such, the renewable electricity generation sectoral target is a part of this target.

Second, clarification is also required over the precise use of the term '*renewable electricity*'. Currently there exist two scales of RES-E generation in the UK in terms of promotion, small-scale and large-scale. Both have dedicated support (subsidy) mechanisms that differ fundamentally in terms of mechanism design and the subsidy level offered for the various renewable energy technologies: the Renewables Obligation (RO) exists for large-scale installations with an installed capacity greater than 5 MW and the Feed-in Tariff (FIT) for small-scale renewable electricity generation with an installed capacity of 5 MW or less.[32] For the purpose of this thesis, large-scale RES-E generation is considered.[33] The reason for this is that large-scale generation is anticipated to provide the vast majority of RES-E in the UK at least to 2020. In 2010, when the small-scale FIT was implemented, the UK Government announced that sub-5MW deployment could deliver approximately 2 percent of final electricity consumption in 2020, equating to around 8 TWh. This is in comparison to the sectoral RES-E target of 114 TWh, of which presumably roughly 108 TWh would come from large-scale, RO-subsidised generation technologies (DECC, 2010c).[34]

---

[32] It is important to note that microgeneration technologies (defined as those technologies of 50 kW rated capacity or below) are supported under the RO scheme (DECC, 2011h). In addition, due to the transition arrangements put in place at the time of the original implementation of the small-scale FIT mechanism whereby a number of RETs were able to chose between accreditation under the RO or the small-scale FIT, certain renewable electricity technologies in the +50 kW to 5 MW (solar PV, wind, anaerobic digestion and hydro-electric projects) are currently supported under the RO (DECC, 2009b). However, there are plans to remove the eligibility of these RETs from the RO mechanism (see Chapter Six, page 192).

[33] There are a number of reasons for omitting small-scale installations from this thesis. The small-scale Feed-in Tariff means that there are different subsidy levels for these technologies in comparison to large-scale installations, whether they are true micro technologies or small-scale installations (for example, 2 onshore wind turbines with a 2 MW rated capacity) with concomitant impacts on investment decisions. In addition, although the potential constraints examined here could also be used in evaluating small-scale RES-E generation, differences between large and small-scale RES-E generation are arguably sufficient to warrant separate, albeit complementary research (including, for example, in planning, grid connection, access to finance, public engagement and opposition).

[34] A Briefing document for MPs by Friends of the Earth (2009: 2) highlighted the limited aims of the sub-5MW mechanism target, stating "*… overall Friends of the Earth is deeply disappointed by the lack of*

Third, this thesis will focus on those renewable electricity technologies that are anticipated to account for the majority of deployment with regard to the 2020 target. This group of key RETs includes onshore wind, offshore wind and certain biomass electricity technologies such as biomass conversion and dedicated biomass. Where relevant, however, other renewable technologies will be examined.

Fourth, this thesis emphasises the deployment of large-scale renewable electricity technologies in terms of installed capacity rather than generation output. Although the 2020 RES-E sectoral target (and any interim targets) is set as a level of generation output, deployment capacity is relevant as this is what the internal and external failures (the potential constraints) act on.

Finally, the 2020 target for electricity generated from renewable energy sources is important; however, it should be viewed as a useful milestone for two particular reasons: as a bench-mark by which to evaluate the progress of RES-E deployment capacity; and as a critical part of the longer-term process to achieve the legally-binding 2050 emissions reduction target set out by the various domestic Climate Change Acts, of which electricity sector decarbonisation is seen as an essential requirement. This thesis, then, is interested in the overall approach to addressing potential constraints rather than simply whether or not the target is achieved and on time.

---

ambition of the feed-in tariff." Indeed, research commissioned by DECC identified a maximum technical potential of 131 TWh from sub-5MW renewable sources in the UK (Pöyry and Element Energy, 2009). However, since the introduction of the FIT on 1st April 2010, over 1GW of total installed capacity has been deployed (equating to around 250,000 installations) (OFGEM E-Serve, 2012). This was driven primarily by two major reasons: a 30% plus reduction in installation costs of solar photovoltaic (the dominant deployed technology: 92% of the total) and mishandling of the proposed subsidy (tariff) cut for solar PV by the UK Government leading to an enormous rush in deployment before the cuts were implemented (Energy and Climate Change and Environmental Audit Committee, 2011). Although a significant deployment, this equates to less than 3 TWh, well below the original 8 TWh 'target' and preliminary evidence indicates that the deployment level post reductions in tariffs particularly for micro solar PV are falling substantially (BusinessGreen, 2012). In addition, the cut-off point for data for this research is 31st December 2010 when sub-5 MW FIT-eligible renewables accounted for just 68 MW (OFGEM E-Serve, 2011b). Given that small-scale solar PV showed the largest increase in installed capacity during 2011-12 of any renewable energy technology, where relevant to this research developments in small-scale RES-E generation will be taken into account (DECC, 2012c). This is particularly important since Gregory Barker, Minister of State for Energy and Climate Change (DECC) recently stated that central government estimates indicated that solar PV could amount to 22 GW of installed capacity despite the recent tariff cuts (Guardian, 2012).

1.6 Limitations

Section 1.5 of this chapter set out the scope of this research. By doing so, this section effectively set out the design limitations of the study. In terms of potential limitations or weaknesses, there are two key limitations with regard to this thesis: (1) the data cut-off point, and (2) wider issues surrounding the topic.

Firstly, the data cut-off point has been set as 31 December 2012. Renewable energy and indeed energy in general is a particularly fast-moving subject area; there has been a multitude of recent, current and proposed changes in policy, legislation and regulation as the government attempts to increase the deployment of renewable electricity technologies in light of renewable energy and climate change targets. The publication of data, however, particularly regarding levels of technology deployment (in installed capacity and generation output) lags behind actual deployment rates. Therefore, a cut-off point of 2012 only enabled access to such data from 2011; data for the entire 2012 year will only be published in December 2013 (DECC, 2012e). A number of problems with this deadline have been encountered, however: planning databases, information on electricity network infrastructure upgrades/extensions and the deployment level of community renewable projects, accessed by the author in late 2012/2013, contained data as of the date they were accessed. This has led to a disjunction in the data cut-off point.

Regarding the second point, this thesis has focused on those large-scale renewable electricity technologies (>5 MW installed capacity) anticipated to contribute the bulk of deployment in the UK to 2020 and beyond with particular emphasis on Scotland and England. However, this ignores a number of related areas that interact with the focus of this thesis in a number of complex and interrelated ways. These include: small-scale renewable electricity technology deployment (sub-5 MW installed capacity); energy efficiency measures; the impact of non-renewable electricity and energy sources to deployment levels; the wider financial and political issues surrounding the UK government's approach to deployment. This list is virtually inexhaustible. Although such issues have been touched on in this thesis (either as relevant background information, or to provide a defence regarding their omission) it is impossible given the type of research carried out here to include these points (in terms of word count, focus and so on).

These two points highlight factors or variables that are out-with the control of this research; however, they do not change the fundamental '*story*' of this PhD which is concerned with evaluating the current UK approach to addressing the potential constraints to large-scale renewable electricity technology deployment to 2020 and beyond from a systemic perspective.

1.7 Thesis structure

The thesis is structured in four parts. **Part I**, of which this chapter forms a part, introduces the subject area to be examined in the thesis and provides a rationale for why this topic has been chosen and outlines the areas of concern within the research topic. **Chapter Two** presents the research methodology utilised in this thesis and sets out the reasoning behind the methodology and the discrete stages involved in the research. Specifically, the internal and external failures and the systemic approach are described. In particular, the identification of the set of internal and external failures is explained. This chapter also determines any potential problems with the adopted methodology and any alternative methodologies that were considered. **Chapter Three** presents a literature review of the way in which government has approached the barriers or constraints to large-scale renewable electricity technology deployment in the UK. This chapter incorporates a historical element, looking at both the previous subsidy mechanisms (the Non-Fossil Fuel Obligation (1990-1998) and the Renewables Obligation (2002-2009) along side wider changes to the electricity 'landscape' in general and renewable electricity policy in particular.

Part II contains three chapters which set out the context regarding large-scale renewable electricity technologies in the UK. **Chapter Four** looks at existing definitions for renewable energy and examines the issue of why renewable electricity requires a level of government support currently unique within the wider approach to energy technology deployment.[35] **Chapter Five** first establishes the critical role of renewable electricity to longer-term renewable and climate change (decarbonisation) objectives before investigating and comparing the economic, technical, resource, social and environmental attributes of the various renewable electricity technologies, in order to develop an understanding of the options available for the various RETs particularly with regard to their deployment within the overall electricity system. **Chapter Six** analyses the historical and current trends in renewable electricity deployment (installed capacity and generation output) in the UK in order to both understand deployment trajectories and determine the level of deployment required to meet the 2020 renewable electricity sectoral target. This chapter also looks at deployment at the sub-national level with particular emphasis on Scotland.

The analytical core of the thesis is contained in **Part III** and comprises three chapters. The first two chapters carry out an evaluation of the current UK approach to addressing potential constraints to deployment. **Chapter Seven** is concerned with evaluating the internal failures on renewable electricity technology deployment. This will be done by examining the reformed Renewables Obligation (2009 onwards) in order to determine what the internal failures are. **Chapter Eight** is concerned with evaluating the external failures on renewable electricity technology deployment. This chapter is split into four main sections reflecting the four external failures examined in this thesis and looks at: the planning system (**Section 8.2**), public participation and engagement (**Section 8.3**), the electricity network (grid) (**Section 8.4**) and policy risk (**Section 8.5**). **Section 8.2** focuses on the planning system in England and Scotland in light of recent legislative and policy changes. This section also examines the key issues relevant to the various renewable electricity technology options. Further, it carries out an analysis of the available planning data for four key technologies anticipated to contribute the overwhelming bulk of capacity to 2020 and beyond. **Section 8.3** looks at the opportunities and barriers facing public participation and engagement, with a focus on

[35] This situation might change with the introduction of the CfD FIT with support for both nuclear power and carbon capture and storage as part of the electricity market reform. Indeed, nuclear power received a similar support for renewables during the early operation of the NFFO subsidy mechanism (see chapter three, section 3.3).

meso-scale developments and community and locally-owned projects. This section also examines the current approach of using financial benefits as a means of securing public consent for onshore wind developments in the UK. **Section 8.4** examines the issue of network capacity and the method of allocation and access to the electricity network with emphasis on the transmission network. This section will look in particular at both the onshore and offshore transmission systems in the UK overall with particular emphasis on Scotland. **Section 8.5** focuses on policy risk with a particular emphasis on the various large-scale renewable electricity subsidy mechanisms (the Renewables Obligation and the proposed Contracts for Difference Feed-in Tariff in so far as it affects deployment under the RO mechanism).

Chapter Nine utilises the analysis of both the internal and external failures presented in chapters seven and eight, respectively, to reveal the systemic interactions of the potential constraints examined here. This is carried out in order to evaluate the current UK approach to addressing the potential constraints to large-scale RES-E deployment from a systemic perspective.

Part IV contains one chapter. **Chapter Ten** sets out the conclusions of the thesis with regard to the research questions. In addition, potential future research work emanating from this thesis will be provided.

It should be pointed out that there will be a certain amount of unavoidable overlap between the chapters of this thesis. This is particularly the case for public participation and engagement and policy risk. Both of these external failures by their inherent nature are necessarily linked to a number of other failures examined in this thesis. As such, public participation and engagement will be examined with regard to both the internal failures (chapter seven) and external failures (chapter eight, sections 8.2, 8.4 and 8.5). In addition, chapters seven and eight (sections 8.2, 8.3 and 8.5) have previously evaluated policy risk with specific regard to the current subsidy mechanism, planning, public participation and engagement and electricity transmission networks, respectively.

References

AEA, 2010. Analysis of Renewables Growth to 2020: Report to DECC March 2010 [online] Available from http://www.decc.gov.uk/publications/basket.aspx?filepath=/assets/decc/11/meeting-energy-demand/renewable-energy/2185-analysis-of-renewables-growth-to-2020-aea-report.pdf&filetype=4&minwidth=true

Bailii, 2012. Sea & Land Power & Energy Ltd versus Secretary of State for Communities and Local Government and Great Yarmouth Borough Council: Judgement: Case No: CO/12120/2010 – 29/05/2012 [online] Available from http://www.bailii.org/ew/cases/EWHC/Admin/2012/1419.html

Baker, P., Mitchell, C. and Woodman, B. 2011. Project TransmiT: Academic Review of Transmission Charging Arrangements: A report produced on behalf of the Gas and Electricity Markets Authority (OFGEM): Final Report, April 18 2011 [online] Available from http://geography.exeter.ac.uk/catherinemitchell/FINAL_PDF_Baker_et_al_to_Ofgem.pdf

Bell, D., Gray, T. and Haggett, C. 2005. Policy, participation and the social gap in wind farm siting decisions. Environmental Politics 14(4): 460-477.

BusinessGreen, 2012. Feed-in tariff payments top £128m over two years: Subsidy scheme prompts 1GW rise in renewable energy capacity since April 2010 launch – 04 July 2012 [online] Available from http://www.businessgreen.com/bg/news/2188822/feed-tariff-payments-gbp128m

Butler, L. and Neuhoff, K. 2008. Comparison of feed-in tariff, quota and auction mechanisms to support wind power development. Renewable Energy 33(2008): 1854-1867.

Clément, A., McCullen, P., Falcão, A., Fiorentino, A., Gardner, F., Hammarlund, K., Lemonis, G., Lewis, T., Nielsen, K ., Petroncini, S., Pontes, M.T., Schild, P., Sjöström, B.O., Sørensen, H.C. and Thorpe, T. 2002. Wave energy in Europe: current status and perspectives. *Renewable and Sustainable Energy reviews* 6(2002): 405-431.

Committee on Climate Change [CCC], 2010. The Fourth Carbon Budget: Reducing emissions through the 2020s – 7 December 2010 [online] Available from http://www.theccc.org.uk/reports/fourth-carbon-budget

Committee on Climate Change [CCC], 2011. Meeting Carbon Budgets – 3rd Progress Report to Parliament – June 2011 [online] Available from http://hmccc.s3.amazonaws.com/Progress%202011/CCC_Progress%20Report%202011%20Single%20Page%20no%20buttons_1.pdf

Connor, P. 2003. UK renewable energy policy: a review. Renewable and Sustainable Energy Review 7(2003): 65-82.

Crown Estates, 2012. Offshore Wind Energy – Our Portfolio [online] Available from http://www.thecrownestate.co.uk/energy/offshore-wind-energy/our-portfolio/

Department of Business, Enterprise and Regulatory Reform [BERR], 2008. Digest of United Kingdom Energy Statistics: 2008 [online] Available from http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html

Department of Energy, 1988. Energy Paper 55: Renewable Energy in the UK – The Way Forward. HMSO.

Department of Energy and Climate Change (DECC), 2009a. UK Renewable Energy Strategy [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/renewable%20energy%20strategy/1_20090717120647_e_@@_theukrenewableenergystrategy2009.pdf

Department for Energy and Climate Change [DECC], 2009b. Consultation on Renewable Electricity Financial Incentives 2009 [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20090722165845_e_@@_ConsultationonRenewableElectricityFinancialIncentives2009.pdf

Department of Energy and Climate Change (DECC), 2010a. Press – Release: Statistical Press Release – Energy Statistics (Reference 2010/072) [online] Available from http://www.decc.gov.uk/assets/decc/statistics/publications/trends/1_20100621151212_e_@@_pn10072.pdf

Department of Energy and Climate Change (DECC), 2010b. Consultation on electricity market reform [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx

Department of Energy and Climate Change (DECC), 2010c. Summary: Interventions & Options: Impact Assessment of Feed-in-Tariffs for Small-Scale, Low-Carbon, Electricity Generation (URN10D/536) – Final Version: 01 February 2010 [online] Available from http://www.decc.gov.uk/assets/decc/consultations/renewable%20electricity%20financial%20incentives/2710-final-ia-feed-in-tariffs-small-scale.pdf

Department of Energy and Climate Change (DECC), 2011a. Energy Trends – December 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/3917-trends-dec-2011.pdf

Department of Energy and Climate Change [DECC], 2011b. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change (DECC), 2011c. Low Carbon Heat Plans Revealed – 26 March 2012 (Press Ref: 2012/029) [online] Available from http://www.decc.gov.uk/en/content/cms/news/pn12_029/pn12_029.aspx

Department of Energy and Climate Change (DECC), 2011d. Renewable Heat Incentive (RHI) Scheme [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

Department of Energy and Climate Change (DECC), 2011e. Digest of United Kingdom Energy Statistics (DUKES) 2010 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/2312-dukes-2011--full-document-excluding-cover-pages.pdf

Department of Energy and Climate Change (DECC), 2011f. UK Renewable Energy Roadmap – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change (DECC), 2011g. Digest of United Kingdom Energy Statistics 2011 [DUKES] [online] Available from http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

Department of Energy and Climate Change (DECC), 2011h. Microgeneration Strategy – June 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/microgeneration/2015-microgeneration-strategy.pdf

Department of Energy and Climate Change (DECC), 2012a. Devolved Administrations [online] Available from http://www.decc.gov.uk/en/content/cms/tackling/saving_energy/what_doing/devolved_admin/devolved_admin.aspx

Department of Energy and Climate Change [DECC], 2012b. Government response to the consultation on the proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: July 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Department of Energy and Climate Change (DECC), 2012c. Digest of United Kingdom Energy Statistics 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/5949-dukes-2012-exc-cover.pdf

Department of Energy and Climate Change (DECC), 2012d. Energy Trends – June 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/5627-energy-trends-june-2012.pdf

Department of Energy and Climate Change (DECC), 2012e. DECC's timetable of statistical releases for twelve months ahead [online] Available from https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics#deccs-timetable-of-statistical-releases-for-twelve-months-ahead

Department of Trade and Industry [DTI], 1994. Energy Paper 62: New and Renewable Energy: Future prospects for the UK. HMSO, London.

Department of Trade and Industry (DTI), 2003. Energy White Paper: Our Energy Paper—Creating a Low Carbon Economy February 2003 [online] Available from /http://www.berr.gov.uk/files/file10719.pdfS

Department of Trade and Industry [DTI], 2007. Meeting the Energy Challenge: A White Paper on Energy May 2007 [online] Available from /http://www.berr.gov.uk/files/file39564.pdfS

Department for Transport [DfT], 2012. Renewable Transport Fuels Obligation [online] Available from http://www.dft.gov.uk/topics/sustainable/biofuels/rtfo

Devine-Wright, F. 2007. Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review – Working Paper 1.4 – February 2007 [online] Available from http://geography.exeter.ac.uk/beyond_nimbyism/deliverables/bn_wp1_4.pdf

Edge, G. 2006. A Harsh Environment: The Non-Fossil Fuel Obligation and the UK Renewables Industry, in K. Mallon (ed), Renewable Energy Policy and Politics: A handbook for decision-making: 163-184. Earthscan.

Electricity Networks Strategy Group [ENSG], 2009. ENSG 'Our Electricity Transmission Network: A Vision for 2020' Full Report [online] Available from http://www.ensg.gov.uk/assets/ensg_transmission_pwg_full_report_final_issue_1.pdf

Energy and Climate Change Committee, 2012. Draft Energy Bill: Pre-legislative Scrutiny: First Report of Session 2012-13: Volume I: Report, together with formal minutes – 17 July 2012 [online] Available from http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenergy/275/275.pdf

Energy and Climate Change and Environmental Audit Committee, 2011. Solar Power Feed-in Tariffs: Ninth Report of Session 2010-12 of the Energy and Climate Change Committee and Tenth Report of Session 2012-12 of the Environmental Audit Committee: Volume I: Report, together with formal minutes, oral and written evidence – 14 December 2011 [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/Feed-in%20Tariff%20Update%20Newsletter%20Issue%208.pdf

Environmental Audit Committee, 2007. Beyond Stern: From the Climate Change Programme Review to the Draft Climate Change Bill – Seventh Report of Session 2007-07: Report, together with formal minutes, oral and written evidence – Tuesday 10 July 2007 [online] Available from http://www.publications.parliament.uk/pa/cm200607/cmselect/cmenvaud/460/460.pdf

Eur-Lex, 2001. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0077:EN:NOT

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Europa, 2011. The EU climate and energy package [online] Available from http://ec.europa.eu/clima/policies/package/index_en.htm

Eurostat, 2012. Electricity generated from renewable sources – Last updated: 21-06-2012 [online] Available from http://appsso.eurostat.ec.europa.eu/nui/show.do

Foxon, T.J., Gross, R., Chase, A., Howes, J., Arnall, A., Anderson, D., 2005. UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures. Energy Policy 33, 2123–2137

Friends of the Earth, 2009. MPs Briefing: Feed-in Tariffs for small scale renewable energy – December 2009 [online] Available from http://www.foe.co.uk/resource/briefings/feed_in_tariff_mps_briefing_dec_09.pdf

Friends of the Earth, 2011. Report – The Dirty Half Dozen – October 2011 [online] Available from http://www.foe.co.uk/resource/reports/dirty_half_dozen.pdf

Friends of the Earth, 2012. Briefing: Electricity Market reform – Updated April 2012 [online] Available from http://www.foe.co.uk/resource/briefings/electricity_market_reform.pdf

Gross, R. and Heptonstall, P. 2010. Liberalised Energy Markets: An Obstacle to Renewables? In, I.Rutledge and P.Wright (eds) UK Energy Policy and the End of Market Fundamentalism. Oxford University Press: Oxford

Guardian, 2012. Greg Barker: 4m homes will be solar-powered by 2020: The government has ramped up solar ambition, despite cut in subsidies available for households – 9 February 2012 [online] Available from http://www.guardian.co.uk/environment/2012/feb/09/solar-power-ambition-uk

Helm, 2008. Energy, the State, and the Market: British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford

Kern, F. and Mitchell, C. 2010. Policy Paradigms as part of the landscape: How do policy paradigms influence attempts to govern transitions? [online] Available from http://www.irspm2010.com/workshops/papers/30_policyparadigms.pdf

Komor, P. 2004. *Renewable Energy Policy*. The Diebold Institute for Public Policy Research.

Lauber, V. 2004. *REFIT and RPS: options for a harmonised Community framework*. Energy Policy: 32: 1405-1414

Lipp, J. 2007. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. *Energy* Vol 35(2007): 5481-5495.

McEwen, N., Bomberg, E. and Swenden, W. 2010. Pushing at boundaries of devolution: Energy and climate change policy in Scotland – Paper presented to the biennial conference of the PSA specialist group on Comparative Territorial Politics: University of Oxford: 7-8 January 2010 [online] Available from http://www.psa.ac.uk/spgrp/4/2010/Ppr/BaCTPSGC2_McEwenNicola_McEwen%20PSA%20Oxford.pdf

Mitchell, C. 1995. The renewables NFFO: A review. Energy Policy 23(12): 1077-1091.

Mitchell, C. 1998. Renewable Energy in the UK: policies for the future. CPRE.

Mitchell, C. and Connor, P. 2004. Renewable energy policy in the UK 1990-2003. Energy Policy 32(2004): 1935-1947.

Mitchell, C., Bauknecht, D. and Connor, P. 2006. *Effectiveness through risk reduction: a comparison of the renewables obligation in England and Wales and the feed-in system in Germany*. *Energy Policy*: 34(3): 297-305.

National Archives, 2008. Climate Change Act 2008 (Chapter 7) [online] Available from http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

National Archives, 2009. Climate Change (Scotland) Act 2009 (2009 asp 12) [online] Available from http://www.legislation.gov.uk/asp/2009/12/pdfs/asp_20090012_en.pdf

National Archives, 2011. Electricity Act 1989 [online] Available from http://www.legislation.gov.uk/ukpga/1989/29/contents

National Research Council, 2008. Public Participation in Environmental Assessment and Decision-Making. The National Academies Press: Washington DC.

Nolden, C. Regulating energy security through the diffusion of innovation – A community perspective [online] Available from http://www.exeter.ac.uk/energysecurity/documents/ese_resources_May2012/Colin_Nolden.pdf

Office of Gas and Electricity Markets [OFGEM], 2011a. The Retail Market Review – Findings and initial proposals – Consultation – Reference: 34/11 – 21 March 2011 [online] Available from http://www.ofgem.gov.uk/Markets/RetMkts/rmr/Documents1/RMR_FINAL.pdf

Office of Gas and Electricity Markets [OFGEM], 2011b. OFGEM E-Serve Issue 3/February 2011: Feed-in Tariff Update [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/Feed-in%20Tariff%20(FIT)%20Update%20Newsletter%20Issue%203.pdf

Office of Gas and Electricity Markets [OFGEM], 2012. OFGEM E-Serve Issue 8/June 2012: Feed-in Tariff Update [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/Feed-in%20Tariff%20Update%20Newsletter%20Issue%208.pdf

Offshore Valuation Group [OVG], 2010. The Offshore Valuation: A valuation of the UK's offshore renewable energy resource [online] Available from http://www.offshorevaluation.org/

Pelc, R. and Fujita, R.M. 2002. *Renewable energy from the ocean*. Marine Policy 26(2002) 471-479.

Platchkov, L., Pollitt, M. and Shaorshadze, I. The implication of recent UK energy policy for the consumer: A report for the Consumer's Association – ESRC Electricity Policy Research Group – University of Cambridge May 2011 [online] Available from http://www.eprg.group.cam.ac.uk/wp-content/uploads/2011/05/ReportforCAFinal100511EPRG.pdf

Pöyry and Element Energy, 2009. Design of Feed-in Tariffs for Sub-5MW Electricity in Great Britain: Quantitative analysis for DECC – Final Report July 2009 (URN 09D/704) [online] Available from http://www.decc.gov.uk/assets/decc/consultations/renewable%20electricity%20financial%20incentives/1_20090715135352_e_@@_relateddocelementpoyryreportonquantitativeissuesinfitsdesignfinal.pdf

Redpoint Energy, 2010. Great Britain Electricity Market Reform [online] Available from http://www.redpointenergy.co.uk/images/uploads/Redpoint_Flyer_-_EMR_v1.pdf

Redpoint Energy, Trilemma UK and the Electricity Policy Research Group [EPRG], 2008. Implementation of EU 2020 Renewable Target in the UK Electricity Sector: Renewable Support Schemes – A report for the Department of Business, Enterprise and Regulatory Reform, June 2008: Version: v1.0 Date: 23/06/08 [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file46778.pdf

Redpoint Energy and Trilemma UK, 2009. Implementation of the EU 2020 Renewable Target in the UK Electricity Sector – RO Reform: A report for the Department of Energy and Climate Change, June 2009 – URN 09D/702: Version: 1.0 Date: 01/07/09 [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/renewable%20energy%20strategy/1_20090715120542_e_@@_redpointimplementationoftheeu2020renewablestargetintheukelectricitysectorroreform.pdf

Redpoint Energy in association with Trilemma UK, 2010. *Electricity Market Reform: Analysis of policy options* – A report by Redpoint Energy in association with Trilemma UK, December 2010: Version: 1.0 Date: 15/12/10 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx

RenewableUK, 2012a. Energy and Climate Change Committee – Written evidence submitted by RenewableUK [online] Available from http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenergy/275/275we18.htm

RenewableUK, 2012b. Offshore Wind Farms [online] Available from http://www.bwea.com/ukwed/offshore.asp

Ringel, M. 2006. Fostering the use of renewable energies in the European Union: the race between feed-in tariffs and green certificates. *Renewable Energy* Vol 31(2006): 1-17.

Scottish Government, 2011a. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011b. 2020 Routemap for Renewable Energy in Scotland [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0118802.pdf

Scottish Government, 2012a. Electricity Generation Policy Statement – Draft Electricity Generation Policy Statement for consultation – 06 Mar 2012 [online] Available from http://scotland.gov.uk/Resource/0038/00389294.pdf

Scottish Renewables, 2012. Initial Response to Call for Evidence on the Draft Energy Bill – 5 June 2012 [online] Available from http://www.scottishrenewables.com/static/uploads/publications/initial_response_to_call_for_evidence_on_the_draft_energy_bill.pdf

Toke, D. 2011. David Toke's green energy blog [online] Available from http://realfeed-intariffs.blogspot.com/search?updated-min=2011-01-01T00:00:00-08:00&updated-max=2012-01-01T00:00:00-08:00&max-results=22

Toke, D. 2005a. Explaining wind power planning outcomes: Some findings from a study in England and Wales. Energy Policy 33(12): 1527-1539.

Toke, D. 2005b. Community wind power in Europe and in the UK. Wind Engineering 29(3): 301-308.

Toke, D., Breukers, S. and Wolsink, M. 2008. *Wind power deployment outcomes: How can we account for the differences?* Renewable and Sustainable Energy Reviews 12 (2008): 1129-1147.

Toke, D. and Lauber, V. 2007. Anglo-Saxon and German approaches to neoliberalism and environmental policy: The case of financing renewable energy. *Energy* Vol 38 (2007): 677-687.

United Nations, 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change [online] Available from http://unfccc.int/resource/docs/convkp/kpeng.pdf

Watson, J., Scrase, I. and Stapleton, L. 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables Target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee.

Wood, G. and Dow, S. 2010. *The Likely Impact of Reforming the Renewables Obligation on Renewables Targets*. International Journal of Energy Sector Management Vol 4(2): 273-301.

Wood, G. and Dow, S. 2011. *What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy*. Energy Policy 39(2011): 2228-2244.

Woodman, B. 2008. Connecting the future: the UK's renewable energy strategy – a report for Greenpeace [online] Available from http://www.greenpeace.org.uk/files/pdfs/climate/connectingthefuture.pdf

Woodman, B. and Mitchell, C. 2011. *Learning from experience? The development of the Renewables Obligation in England and Wales 2002-2010*. Energy Policy 39(2011): 3914-3921.

Chapter Two

Chapter Two
Methodology

2.1 Introduction

This chapter introduces the research methodology and analytical framework used in this thesis. Section 2.2 sets out the analytical framework that guides the analysis of this thesis. Section 2.3 identifies and provides justification for the internal and external failures to large-scale renewable electricity technology deployment in the UK examined in this thesis. Section 2.4 discusses the research methodology, based on the systemic approach. In particular, this section sets out the reasoning underlying the choice of methodological approach, the discrete stages involved in carrying out this research and any problems arising from the methodology adopted. Section 2.5 further describes the underlying approach. Section 2.6 sets out the limitations of the methodology used in this thesis.

2.2 Analytical framework

Figure 2.1 (page 46) shows the analytical framework and graphically portrays the research issue that this thesis seeks to address. The first two parts serves to emphasise the scale of the sectoral target and the existence of the internal and external failures that act as constraints to large-scale renewable electricity technology deployment in the UK (Part A). Further, it highlights the gap in extant knowledge and analysis due to the absence of existing research and modelling meeting the three criteria required to produce a credible evaluation of whether or not the UK will meet the target (Part B).[36] This has potentially profound implications for the rigorous and credible basis of the projections

[36] The approach underlying the internal and external failures (including what they are and justification for how the list was chosen and what other additional problems facing large-scale RET deployment were excluded) and the three criteria upon which it is based (comprehensive, in-depth and systemic) are discussed in more detail in section 2.3.

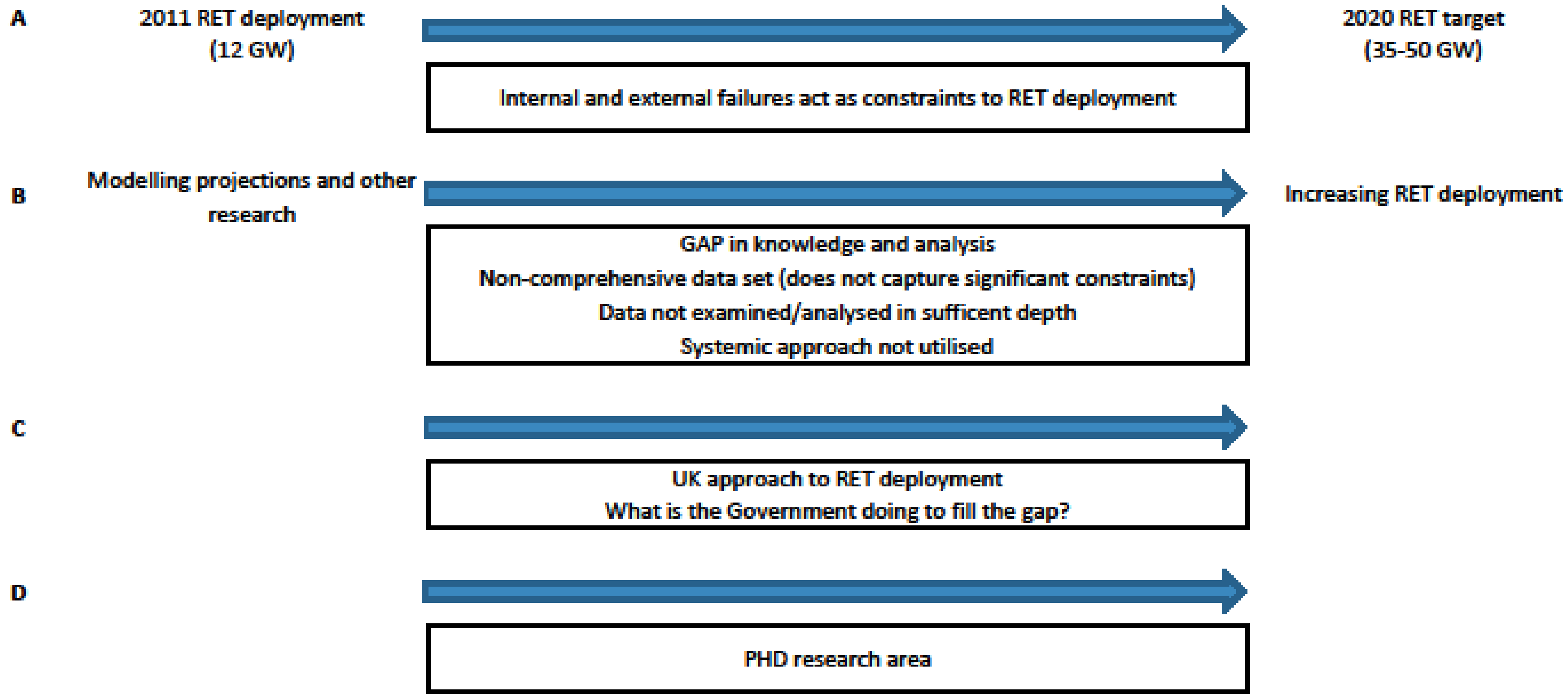


Figure 2.1 Graphical representation of the research issue (Analytical framework)

Note: The blue arrow represents the gap or research issues to be addressed in this dissertation commissioned by the UK government. The key issue and the subject of this research then, regard what is being done to address this 'gap' in knowledge and analysis in evaluating whether or not the UK will meet the target (Part C). What is the UK government approach to addressing the constraints to large-scale renewable electricity technology deployment? In other words, what is being done to address the gap by way of addressing the multiple constraints? Will it be sufficient to address the potential constraints in order to increase deployment to the amount required? In a sense, this thesis is reassessing the modelling projections in light of changed assumptions. This is the focus of the PhD research (Part D). The substantial policy, regulatory and legislative changes that have been recently enacted or proposed to the 'renewable electricity landscape' also need to be taken into consideration.[37]

2.3 The internal and external failures

There are three criteria upon which the internal and external failures method and thus the systemic approach are based upon:

(i) The set of constraints included in the internal and external failures needs to be comprehensive. They have to include the significant constraints that effect large-scale renewable electricity technology deployment.

(ii) The internal and external failures need to be examined in sufficient and equal depth of analysis.

The first two criteria (i and ii) form the basis that enables the third criteria to be met, to capture the systemic interactions of the internal and external failures:

[37] Changes to the non-renewable electricity landscape can and do have significant impacts on renewable policy. As such, and where applicable, these are also considered in the thesis (see in particular Part II of the thesis).

(iii) Individual constraints can interact with each other in a way(s) that could aggravate the impact of the potential constraint(s) in a system-wide or systemic way.

Table 2.1 (page 49) sets out the list of internal and external failures included in this thesis and provides a summary. Looking at the internal failures, these are derived from the overall type, design and operation of the subsidy mechanism, the Renewables Obligation. There are six internal failures that will be examined in this thesis: focus on low costs; complex mechanism, price/revenue risk; favours large companies; investment risk; and market chooses technology. These are analysed in chapter seven. In addition, there are four external failures: planning, grid, public participation and engagement and policy risk/uncertainty. These are analysed in chapter eight. The comprehensive and in-depth analyses of both the internal and external failures are then used to reveal the systemic interactions of the potential constraints in chapter nine of the thesis. This is carried out in order to evaluate the current UK approach to addressing the constraints to large-scale renewable electricity technology deployment from a systemic perspective.

The method by which the set of internal and external failures are identified and selected for inclusion in this thesis in order to be comprehensive is also crucial since the conclusions of the thesis are strongly grounded in the use of these failures. It is not argued here that the set of constraints (the internal and external failures) analysed in this thesis is exhaustive in the sense that they capture every single barrier or problem facing large-scale renewable electricity technologies in the UK. However, the critical distinction is that the inclusion of the set of chosen internal and external failures (see Table 2.1) represents a list of those constraints that affect the actual deployment of the technologies in terms of installed capacity and not the operation of the technologies (at the point where renewable electricity generation occurs). As stated in chapter one (section 1.6), a focus on deployment is one of the key aims of the thesis.

The selected set of internal and external failures are identified via three main initiatives. Firstly, during the research and analysis that constitutes the literature review that

Table 2.1 The internal and external failures

Internal failures		Issues
1	Focus on low costs	How will renewable electricity technology deployment be affected by a focus on low costs?
2	Complex mechanism	How complex is the mechanism in terms of design? Is it administratively burdensome? What level of knowledge and expertise is required to operate within the mechanism? Are there different requirements for different technologies; Does this act as a barrier to participation, and if so, in which ways?
3	Price/revenue risk	Are the key revenues offered by the subsidy mechanism fixed or guaranteed?
4	Favours large companies	Does the RO discriminate in favour of a particular model of ownership?
5	Investment risk	How will access to capital be impacted on by lender requirements?
6	Market chooses technology	What are the implications of the technology choice being left to the market?
External failures		**Issues**
1	Planning	How does the planning system facilitate the adoption of renewable electricity technologies? Does it take into account the different scales of deployment?
2	Grid	Is there sufficient grid infrastructure capacity? What are the rules governing the allocation and access to grid infrastructure?
3	Public participation and engagement	How is the role of the public dealt with in regard to the decision-making process?
4	Policy risk/uncertainty	Is the government approach stable and predictable? Are there long-term credible objectives?

identifies and analyses the internal and external failures on RET deployment from a historical perspective, covering the period 1990 to 2009 (chapter three). Secondly, from an investigation of extant research and modelling assessing the constraints to large-scale RET deployment including research published by the thesis author during the duration of the thesis (chapter one, section 1.2). In particular, the literature review chapter draws heavily on the authors published work. Thirdly, this research and analysis of the internal and external failures was carried out in more depth in chapter seven and eight (to meet the first and second criteria) and the systemic interaction between the constraints were identified and evaluated (to meet the third criteria) (chapter nine). These three initiatives enabled the identification of the potential constraints to large-scale RET deployment from both (i) the extant literature, and (ii) the analysis and evaluation of the extant literature and new research carried out during and as an integral part of this thesis.

Other barriers excluded from the internal and external failures approach include issues of intermittency, flexibility of operation, the requirement of back-up generation and resource availability. Instead of acting on actual deployment, these types of barrier affect the operability of certain renewable electricity technologies within the wider electricity system. As such, they are not included in the set of internal and external failures. The significance of these issues is not under-estimated, however, and are analysed along with other factors in part II of the thesis.

2.4 Research methodology

The analytical framework developed in the previous section was then used to carry out an evaluation of the current UK approach to large-scale renewable electricity technology deployment to 2020 and beyond by adopting a systemic approach framework to determine whether or not the UK will be successful in addressing the potential constraints – the internal and external failures – to deployment. This is approached by answering three specific research questions. What are the implications of the current UK approach to addressing potential constraints to renewable electricity technology deployment to 2020 and beyond? How would a UK response based on a systemic approach to renewable electricity technology deployment perform compared to the current UK Government's efforts to address potential constraints? What could the systemic approach offer to policy makers?

This thesis integrates the analytical research method with the systemic approach. The systemic approach adopted here is not a novel one, derived as it is from General System Theory in the 1940s (Bertalanffy, 2003) and later with the development of Systems Thinking (Bánáthy, 2000). In general, both approaches incorporate several similar key tenets: interdependence of objects and their attributes and holism. These provide the ability to reveal emergent properties not possible to detect by other types of analysis (Bertalanffy, 2003; de Rosnay, 1997; Lars, 2006). Particularly relevant to this thesis is the point that the systemic approach can be applied to problem solving by looking at the problems as parts of an overall system rather than reacting to specific parts, outcomes or events. Put simply, the systemic approach sets out that fully understanding why a problem occurs and persists can only be realised by understanding the parts in relation to the whole. This underlies the rationale for the methodological approach adopted in this thesis, as highlighted by the quote by Baker *et al* (2011) in chapter one. Although the systemic approach is not new, to this author's knowledge it has not been previously used to investigate the research issues and questions of this thesis.

The analytical research method involves the researcher having "… *to use facts or information already available, and analyze these to make a critical evaluation of the material*" (Kothari, 2004). Further, analytical research can be used to reveal the underlying causes, by suggesting or explaining why or how something is happening: "*An important feature of analytical research is in locating and identifying the different factors (or variables) involved*" (Bradford, 2007). An additional trait of the analytical method is that it first isolates and then concentrates on the individual factors. In other words, it enables the study of the nature of interaction. For the purpose of this thesis, this is important in order to separate and identify the internal and external failures. Further, each failure once determined can be analysed in-conjunction with the proposed solution to address it. However, this particular method only allows this process to occur in isolation.

The strength of the systemic approach to this thesis is that, in contrast to the reductionist approach of the analytical research method, the systemic approach unifies and concentrates on the interaction between the failures and the government's initiatives to address them. By studying the effects of interactions, it avoids the typical response to such constraints embodied by the current approach which operates on the implicit assumption that each failure, once determined can be effectively addressed with its own 'elegant' solution in isolation. In other words, the integrated analytical research method and the systemic approach permit the teasing out of the systemic interactions of the individual internal an external failures and the evaluation of the current UK approach to addressing them. Importantly, the systemic approach understands problems in a contextual framework. Further, the analytical research method and the systemic approach are more complementary than opposed despite neither being reducible to the other (de Rosnay, 1997).

The research methodology, then, involves the following stages: (1) An academic, scientific-based analysis of renewable energy and large-scale renewable electricity supply technologies; (2) Identification and assessment of the internal and external failures – the potential constraints; (3) A textual analysis of key policy documents and legislation and the decisions taken by government; and (4) the application of the systemic approach in order to carry out an evaluation of the UK approach to RES-E deployment.

(1) *An academic, scientific-based analysis of renewable energy and large-scale renewable electricity supply technologies*: This will establish both the legal and non-legal definitions of renewable energy and place renewable energy in general and large-scale renewable electricity technology deployment in particular in the context of the overall electricity system. Current levels of RET deployment (in installed capacity and generation

output) is also analysed in order to determine the baseline contribution of RES-E with regard to the target.

(2) An i*dentification and assessment of the internal and external failures – the potential constraints*: As discussed elsewhere in this chapter, this thesis draws on the '*internal and external failures*' approach originally developed and elaborated in Wood (2010) and Wood and Dow (2010, 2011). This approach has already been discussed in detail in section 2.3 of this chapter and chapter one.

(3) *A textual analysis of key policy documents and legislation*: This stage involves the identification and critical analysis of key policy documents and legislation that form the basis of the UK Government's approach to addressing the barriers to RES-E deployment and thus meeting the 2020 sectoral target. This will include relevant material at the EU, UK and, where appropriate, the sub-national level. Crucially, the selected material has to be that which is actively utilised by the government. This will clarify what the UK approach entails with regard to addressing the potential constraints to deployment in order to reach the RES-E sectoral target.

(4) *The application of the systemic approach in order to carry out an evaluation of the UK approach to RES-E deployment*: Drawing on the previous stages, the fourth stage will involve applying the systemic approach to evaluating potential constraints (the internal and external failures) to determine whether or not the gap between the modelling projections and the target will be addressed and thus whether or not the target will be met. This will establish how the internal and external failures relate to the attainment of increasing large-scale RET deployment by determining the relationship between the potential constraints and the UK approach to the sectoral target.

2.5 Adopting Approaches: A Systemic Approach to Evaluating Internal and External Failures

This chapter has previously discussed both the benefits of adopting a systemic approach to internal and external failures in evaluating potential constraints to renewable electricity deployment and the need for such an approach. The focus of this section will be to describe the underlying approach.

Renewable electricity supply technologies represent a distinctly heterogeneous category. Table 2.2 (page 55) shows the six major renewable energy technology '*families*' and associated sub-categories: wind power (onshore, offshore), marine (wave, tidal stream, and tidal range), hydro power (reservoir, run-of-river), biomass (landfill gas, sewage gas, co-firing, anaerobic digestion and other biomass), solar photovoltaic and geothermal (natural, geo-pressured, hot dry rocks and magma). In addition, a number of these technologies have been specifically developed for the small or micro (or pico) scale: onshore micro-wind, micro hydro reservoir and micro solar photovoltaic). With the exception of solar photovoltaic, the latter (small-scale) category is not examined in this research. In addition to small-scale (defined as <5 MW of installed capacity) and large-scale RETs (>5 MW installed capacity), there is also increasing attention on what is termed '*meso-scale*' renewables defined as "*between that of the end user* [typically at the building level] *and centralised provision* [typically a larger-scale wind farm above 50 MW]" (Watson *et al*., 2010). Therefore, RETs exist at a number of scales. In general, RETs do not conform to the characteristics of the current energy system, dominated as it is by large-scale, centralised power stations situated within a transmission and distribution electricity network designed to enable the delivery of bulk quantities of electricity. In contrast to fossil fuel and nuclear power stations, renewables are small-scale and geographically dispersed. However, again, there exists considerable variation depending on the technology in question.

RETs incorporate many different technologies and fuels with very different characteristics. Such technologies are typically long-lived assets, with operational life-spans ranging from twenty to fifty plus years, although there is considerable

Table 2.2 Categorisation of the major renewable electricity technologies

Technology family	Technology sub-categories		
Wind	Onshore wind	Micro-wind	
		Macro-wind	
	Offshore wind	Fixed	
		Floating [1]	
Marine	Wave [2]	Shoreline	Fixed
		Nearshore	Floating
		Offshore	Tetherd
	Tidal	Stream	
		Barrage	
Hydro	Hydro	Micro-hydro reservoir	
		Run-of-river	
		Macro-hydro reservoir	
Solar PV	Solar PV	Micro-PV	Off-grid
		Macro-PV	On-grid
Biomass	Landfill gas		
	Sewage gas		
	Co-firing		
	Anaerobic digestion		
	Other biomass [3]		
Geothermal	Natural		
	Geo-pressured		
	Hot dry rocks		
	Magma		

Note: [1] Floating offshore wind turbines are still in the development stage with very few single unit devices deployed for testing in the marine environment. [2] There are around 200 wave devices currently patented, highlighting the many different configurations available for wave energy converters. As such, there are a number of proposed classification systems based on location (fixed, floating, tethered) or geometry and orientation (terminators, attenuators, point absorbers) (Clément et al., 2002; Pelc and Fujita, 2002). [3] Other biomass includes municipal solid waste combustion (biodegradable part only), animal waste (including farm waste digestion, poultry litter combustion and meat and bone combustion) and plant biomass (including straw and energy crops).

uncertainty with regard to those relatively untested technologies lacking any real or significant deployment history. This is particularly the case for marine RETs and offshore wind. Not all technologies or fuels are limited to the electricity sector. Biomass can also be used in the heating and cooling and transport sectors, and such end-use flexibility can lead to conflict or sectoral prioritisation over utilisation, particularly as the non-renewable electricity sectors are under-performing in comparison to the electricity sector. Importantly, they are at different levels of research, development and deployment. This can also be the case at the sub-category level for technology types (for example, wind power). In any given time period, there will be those technologies that can contribute towards the renewable (or low-carbon) targets and those on the horizon that require more research, support and time in order to reach deployment at the scale required. Such differing levels of maturity and market penetration will play an important role in whether and when they will evidence strong uptake (pull) by the market.

It is clear from the above that barriers to deployment will act upon individual renewable electricity technologies in a number of different and, importantly, technology-specific ways given the widely varying attributes of the technologies. Such potential constraints can also operate over different time-scales, with resultant short, medium or long lasting effects on the subsequent rate of deployment. In addition, constraints can have an aggravated impact over time, as has been evidenced in the UK particularly with regard to planning, or grid connection and policy risk. As discussed previously in this chapter, however, the constraints or barriers examined in this thesis do not act purely in isolation. The use of the systemic approach to evaluating the internal and external failures seeks to examine the interaction of potential constraints: assessing the cumulative or in-combination interaction of the various potential constraints can aide in revealing what options exist for choosing various renewable electricity supply technologies in increasing deployment capacity and/or the sectoral target. In other words, the adoption of this particular approach can, by examining the system, highlight where the internal and external failures lie and determine the trade off's that exists with regard to addressing the failures.[38] Specifically, this approach can show not only where trade off's should and could be made in the UK approach to large-scale RET deployment but also, critically, justifies that such trade-off's between various options is a valid course of action.

Also the systemic approach to potential constraints utilised here does take into account how the target is reached. In other words, the approach taken is deemed important, rather than simply whether or not the target is attained. This contrasts with the EU 2009 Renewables Directive (2009/28/EC) which is not required to do so: the important point is whether or not the target is reached at both the Member State (in this case, the UK) and the overall EU level. The approach adopted in this thesis, then, permits the exploration of whether or not the UK approach to deploying RETs (and thus increasing generation output, for example in line with the sectoral target) could have been done in a different way. In addition, this leads on to the following questions: What are the systemic implications of missing the target? What are the systemic implications for future (post-2020) targets if the current target is met? What are the policy implications for different technologies? Importantly, such questions could not have been examined if a focus on individual technologies or projects was pursued instead of a systemic evaluation of the overall system utilised in this research.

2.5 Limitations of the methodology

This thesis does not implicitly explore the issue of economics, and as such neither attributes values nor carries out a relative valuation of the various large-scale renewable electricity technology options.[39] This is deliberate for two main reasons. An economic assessment is out with the scope of this thesis and the author's key research

---

[38] The internal and external failures will be different not only for different RETs but also for different mechanisms, including the NFFO, the RO and undoubtedly the proposed contracts for difference feed-in tariff (CfD FIT).

[39] This thesis does, however, look at these issues from a more systemic perspective (see in particular chapters five, seven, eight and nine).

strengths. Importantly, a focus on economics *per se* could obscure the aims of the thesis (see below).

The Evaluations of energy policy focus on a number of rationale including the effectiveness or economic efficiency of a policy initiative against set objectives (International Renewable Energy Agency [IRENA], 2014; Schmalensee, 2011). The effectiveness of policy is typically carried out by

> "*…measuring and benchmarking the outcomes renewable energy policies have delivered… The simplest indicators measure installed capacity or electricity output and growth rates thereof, either in absolute or percentage terms. More sophisticated approaches assess deployment against a country's overall potential, measured over a period of time. Estimates of resources and technical and economic constraints are needed for calculating potential* [alongside additional indicators including] *progress towards targets, share of electricity generated and attempts to capture the maturity of the market for renewable energy.*" (IRENA, 2014: 7).

The economic efficiency of policy is defined as "… the ratio of outcomes to inputs, for example, renewable energy targets realised for economic resources spent." (IRENA, 2014: 20). Quantitative evaluation tools including cost-effectiveness analysis and cost-benefit analysis are exemplified by the HM Treasury guidance document '*Green Book: Appraisal and Evaluation in Central Government*' (HM Treasury, 2011). The 'Green Book' is "… designed to promote efficient policy development and resource allocation across government" (HM treasury, 2011: 1). The process for appraisal and evaluation are fundamentally based on two pre-requisites being met: a clearly identified need for policy intervention, and that the benefits out-weigh the costs.

However, this focus on simple effectiveness proxy indicators and whether or not policy has been economically efficient in terms of the resource expended in delivering renewable energy runs the risk of failing to take into account the complexity of the overall 'system' and undervaluing important qualitative processes. In particular, it could obscure the teasing out of the systemic interactions of the internal and external failures on RET deployment.

References

Baker, P., Mitchell, C. and Woodman, B. 2011. Project TransmiT: Academic Review of Transmission Charging Arrangements: A report produced on behalf of the Gas and Electricity Markets Authority (OFGEM): Final Report, April 18 2011 [online] Available from http://geography.exeter.ac.uk/catherinemitchell/FINAL_PDF_Baker_et_al_to_Ofgem.pdf

Bánáthy, B.H. 2000. Guided Evolution of Society: A Systems View (Contemporary Systems Thinking). Springer

Bradford, 2007. Introduction to Research and Research Methods [online] Available from http://www.brad.ac.uk/management/media/management/els/Introduction-to-Research-and-Research-Methods.pdf

De Rosnay, J. 1997. Analytic vs. Systemic Approaches [online] Available from http://pespmc1.vub.ac.be/ANALSYST.html

HM Treasury, 2011. Green Book: Appraisal and Evaluation in Central Government [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

International Renewable Energy Agency, 2014. Evaluating Renewable Energy Policy: A Review of Criteria and Indicators for Assessment – January 2014 [online] Available from http://www.irena.org/DocumentDownloads/Publications/Evaluating_RE_Policy.pdf

Kothari, C.R. 2007. Research Methodology: Methods and Techniques – Second Edition [online] Available from http://www.limat.org/data/research/Research%20Methodology.pdf

Lars, S. 2006. General Systems Theory: Problems, Perspectives, Practice – Second Edition. World Scientific Publishing Co Ltd

Schmalensee, R. 2011. Evaluating Policies to Increase the Generation of Electricity from Renewable Energy – CEEPR WP 2011-008 – May 2011 [online] Available from http://web.mit.edu/ceepr/www/publications/workingpapers/2011-008.pdf

von Bertalanffy, L. 2003. General Systems Theory: Foundations, Development, Applications – Revised Edition. George Braziller Inc

Chapter Three
Literature Review

3.1 Introduction

This chapter critically examines the extant literature in order to determine the context in which large-scale renewable electricity technology deployment has occurred, and the way in which government previously approached the barriers or constraints to deployment. As such, it is necessary to approach the literature review from a historical perspective covering the period from 1990 to 2009. This will highlight the issues of relevance to this thesis, and form the background to the analytical core of the thesis contained in Part III. Importantly, the literature review will contextualise the internal and external failures. Further, this chapter draws heavily on the justification for the PhD section in the introductory chapter to the thesis (chapter one, section 1.2) which identified the lack of research evaluating deployment constraints based on a comprehensive dataset, analysed in-depth that takes into account the systemic interactions of the constraints.

Section 3.2 will look at the changing context and priorities in which renewable energy has and continues to operate. Section 3.3 and 3.4 will look at the Non-Fossil Fuel Obligation and the Renewables Obligation respectively.

3.2 The Depoliticalisation and Repoliticalisation of UK energy policy

Government led support for renewable energy sources, in terms of research and development, and providing policy to develop their potential, can be traced back to the oil crises of the 1970s (Connor, 2003; Wilson, 2012). Importantly, the renewable financial support mechanisms that were implemented from the early 1990s onwards have differed from previous support primarily due to four main factors that have significantly affected energy markets and energy politics worldwide. The four main factors were and increasingly still are: privatisation, liberalisation, climate change and security of supply (Helm, 2008). These factors have resulted in a depoliticalisation (privatisation and liberalisation during the 1990s) and a subsequent repoliticalisation of energy policy (from approximately 2000 onwards, with climate change and security of supply concerns).

The depoliticalisation of energy policy, whereupon energy was treated as just another commodity and left to market forces was becoming widespread from the 1980s onwards. This approach has been encapsulated by the then Secretary of State for Energy, Nigel Lawson's '*The Market for Energy*' speech in 1982:

> "*I do not see the government's task as being to try and plan the future shape of energy production and consumption. It is not even primarily to try to balance UK demand and supply for energy. Our task is rather to set a framework which will ensure that the market operates in the energy sector with the minimum of distortion*" (Helm *et al*., 1989: 27).

In other words, as Helm (2007: 1) states clearly:

> "*The task of energy policy was to get the state out of the energy sector and the instruments were privatisation, liberalisation and competition.*"

In brief, liberalisation of the electricity markets entails breaking the natural monopolistic characteristics of electricity supply through vertical de-integration of generation, transmission, distribution and supply. Instead of controlling the energy sector by essentially fixing the price and quantities, the market determined both. As such, governments have had to establish regulators[40] and regulations to enforce a

[40] Established by the Utilities Act 2000, the Office of Electricity and Gas Markets (OFGEM), as a non-ministerial Department, is the independent regulator of both the electricity and downstream natural gas markets and operates under the direction and governance of the Gas and Electricity Authority (GEMA) (National Archives, 2000). OFGEM was created through the merger of the previous regulators for electricity (Office of Electricity Regulation, OFFER) and gas (Office of Gas Supply, OFGAS) via the 1989 Electricity Act and the Gas Act 1986, respectively (National Archives, 1986, 1989). Initially set up as an economic regulator with the primary duty to protect the interests of existing and future consumers wherever appropriate by promoting effective competition, OFGEM's duties and core regulatory duties have been revised to include: to incorporate security of supply and climate change objectives explicitly into its primary obligation; Environmental and Social Guidance to balance the regulators conflicting duties; to protect vulnerable customers; and to administrate government programmes on behalf of the

system of competition. In the UK, the electricity restructuring process began with the Electricity Act 1989 coming into force (National Archives, 1989). The process initially commenced with the sale of state assets (privatisation) in 1990-91 with the incorporation of liberalisation and competition occurring throughout the 1990s. Indeed, liberalisation is an on-going process.[41]

This has obvious implications for government support for renewable energy[42]: the liberalised and privatised energy market in which most countries created and continue to operate their policy instruments to support renewable energy sources represent a fundamental shift in energy systems – from regulated and direct government ownership to a competitive, open market. As a result, governments lost some control and influence over the resultant competitive energy system to the market (see Komor 2004; cf. Helm, 2007). The main reasons for liberalisation were to introduce competition, lower prices for consumers, reduce subsidies and remove liabilities from government balance sheets (Helm, 2007). For renewables, this meant the creation of a new environment in which the various renewable electricity technologies, representing a broad range of technologies at different levels of maturity and exhibiting various attributes, must compete not only with more established technologies including coal, oil, gas and nuclear power but also, with other renewables (as will be seen in section 2.4) this was particularly the case for renewables under the UK's Renewables Obligation mechanism).

In addition, another outcome of the drive for a more market driven energy sector via the tools of privatisation, liberalisation and competition, has been the focus on cost-cutting:

Department of Energy and Climate Change (DECC) such as the Renewables Obligation and the small-scale Feed-in Tariff (National Archives, 2004; National Audit Office [NAO], 2010; OFGEM, 2012; Oxford Energy Research Associates [OXERA], 2012).

[41] The first liberalisation directives were adopted in 1996 (electricity) and 1998 (gas) and transposed into Member State's legal systems by 1998 (electricity) and 200 (gas). The second liberalisation directives were adopted in 2003 and transposed into national law by Member States by 2004 (with some provisions by 2007). The third liberalisation directive was adopted in 2007 and entered into force in 2009 (Europa, 2012b; OFGEM, 2012b).

[42] The implication for all other energy technologies has been no less significant.

> "*For politicians and regulators, such markets were widely believed to be a one-way bet: prices could only go down towards marginal cost, as the sunk costs were expropriated for the benefit of customers… But such favourable conditions could… only last for as long as supply exceeded demand. As electricity prices fell in Britain, the industry vertically* [re]*integrated and concentrated. Then, eventually, as the assets aged and new investment slowed down, the capacity margin tightened… such an energy policy could not be assumed to deliver such a happy coincidence of outcomes permanently… By expropriating the sunk costs through more marginal cost pricing, and being seen to allow this to happen, investment was deterred and the credibility of the overarching energy policy framework was undermined. The focus on cost-cutting – sweating the assets – reduced the resilience of the system to shocks, and investment was limited to areas where there was some (typically artificial) protections… gas CCGTs… during the early years and … and then renewables.*" (Helm, 2007:17-21).

Given the importance of climate change and security of supply concerns (see below), both low carbon technologies, nuclear power and carbon capture and storage (CCS), along with gas (under the label of a '*transition and lower-carbon fuel*') also look highly likely to fall within the protective sphere as the need to replace existing generation infrastructure becomes more critical. In other words, the evolving situation has opened the door to renewable and non-renewable electricity sources (Pollitt, 2008).

Climate change and security of supply concerns are the other dominant factors of recent years and has led to a repoliticalisation of energy policy (Helm, 2007). The UK has signed up to the Kyoto Protocol, adopted in 1997, requiring a reduction in greenhouse gas emissions (GHG) of 12.5% by 2012 against the baseline of 1990 emission levels (United Nations Framework Convention on Climate Change [UNFCCC], 2007). Decarbonisation of the electricity sector is viewed as essential to meeting the UK's climate objectives as set out in the domestic Climate Change Acts: an 80 percent reduction in greenhouse gas emissions from 1990 levels by 2050 (for the UK overall, and at the national administrative level for Scotland), with diverging interim targets for 2020 (34 percent and 42 percent reductions on 1990 levels for the UK and Scotland respectively) (National Archives, 2008, 2009).[43] Regarding the electricity sector, the UK

[43] The Climate Change Act 2008 (encompassing the UK overall) was enacted on the 26 November 2008 (National Archives, 2008). The central pillars of the legislation are the legally-binding targets for reducing GHG emissions by 2020 (the interim target) and 2050. These correspond with climate science and international and European Union (EU) commitments, and a series of five-yearly carbon budgets which

government has also set a legally-binding target of a 50 per cent reduction in GHG emissions by 2027 (Department of Energy and Climate Change [DECC], 2011). Both climate change and energy security concerns have also provided drivers for the repoliticalisation of energy policy. Two European Union (EU) directives (2001/77/EC and 2009/28/EC) have set renewable energy specific targets for Member States, the former directive focusing explicitly on promoting renewable electricity (RES-E) generation whilst the latter directive set an overall legally-binding renewable energy target of 15 percent of total energy to be generated from renewable energy sources for the UK (incorporating the electricity, heat and cool and transport sectors) (Eur-Lex, 2001; Europa, 2009). This has been translated into a renewable electricity sectoral target of around 30 percent for the UK by 2020 (DECC, 2009) whilst the Scottish Executive has recently increased the level of ambition for 2020 to a 100 percent equivalent RES-E target for Scotland (Scottish Government, 2011).

Climate change, however, provides a completely new dimension to energy policy. It not only requires a massive switch from carbon-intensive to low carbon economies but has driven governments to create policies to incentivise privatised energy companies (many of which have re-vertically integrated) to support renewables. This is a complex and difficult task because it requires renewable energy support policies (and other climate change mitigation measures) to become more integral parts of energy policy within a privatised-liberalised energy framework. Importantly, renewables are for the moment generally a less attractive proposition in comparison to conventional fuels (gas, coal and oil).

---

set maximum UK emissions on the trajectory to the 2020 and 2050 targets. The Act also established the independent Committee on Climate Change (CCC) primarily to advise the government on key matters under the Act and in monitoring and reporting on the government's progress under the Act. The Climate Change (Scotland) Act received Royal Assent on the 4 August 2009 (National Archives, 2009). Apart from differences in interim targets, another major difference between the Climate Change Acts of the UK and Scotland are that, in contrast to the five-yearly UK carbon budgets, the Climate Change (Scotland) Act requires Scottish Ministers to set annual targets in secondary legislation for Scottish emissions from 2010 to 2050 (Scottish Government, 2011a).

Security of supply concerns has also become an increasing concern for government. Security of supply is a complex issue, concerned not just with the physical access to energy but also includes what is termed energy security: consumer access to energy at prices that are both affordable and not excessively affordable. Indigenous supplies of gas and oil have been in decline for a number of years.[44] The UK's electricity (and energy) system is also undergoing considerable change: over the next decade around a quarter (around 20GW) of existing generation capacity will close. This is primarily due to the age of the assets (particularly nuclear) and EU-led environmental legislation including the Large Combustion Plant Directive (LCPD) namely coal.[45] Although on the one hand this appears to increase the risk of tightening capacity margins, on the other hand it offers a '*window of opportunity*' for the UK electricity generation landscape: the loss of such capacity needs to be replaced, particularly as electricity demand is likely to increase. Alongside the RES-E sectoral target, the UK government has initiated a programme to build a new civil nuclear power fleet and has ambitions to develop carbon capture and storage (CCS) in order to meet primarily climate change and renewable targets. However, it also opens up the possibility for the construction of new conventional generation partly due to concerns over capacity margins and partly due to the intermittent and typically low-load factors characteristic of renewable electricity technologies, particularly wind power.

It is this context that has led to what has been termed the '*Policy Trilemma*': how to square the competing objectives of: reducing greenhouse gas emissions ('*low carbon*'); securing energy supply ('*secured supply*'); and obtaining the lowest possible energy bills for consumers ('*low prices*') (DECC, 2009). This has led to the situation where

---

[44] This does not necessarily reflect that domestic sources are 'running out': it is also a reflection of the level of investment in exploration, drilling, exploitation and storage, which are primarily dependent on demand and investment/regulatory and tax issues.

[45] The LCPD (Directive 2001/80/EC) aims to reduce acidification, ground level ozone and particulate matter pollution (sulphur dioxide, nitrogen oxides and dust) from large combustion plants (>50 MW installed capacity) amongst other plant and processes. As such the LCPD has established emission limit values which constrain the operating lifespan of the power station in question (Department for Environment Food and Rural Affairs, 2012).

> "[Energy] *Policy activity has accelerated almost breathlessly, with a succession of White Papers, consultations, Acts of Parliament and new institutions.*" (Pearson and Watson, 2012: 2).

Invariably, this has required significant policy, legislative and regulatory changes to the electricity '*landscape*' in order to tackle the policy trilemma and to address the barriers to deployment that have arisen as the government has approached the challenge of meeting the various renewable targets.

The context discussed above has also been further complicated by the devolution of powers to the constituent countries of the UK. The legislative framework for devolution is set out in the Scotland Act 1998, the Government of Wales Act 1998 and the Northern Ireland Act 1998 (Legislation, 1998a, b, c).[46] Importantly, there is no devolution of powers to England. Significantly, there are different levels of devolved responsibilities due to the fact that the UK system of devolution is asymmetric. Critically, overall energy policy is reserved to the UK Government and DECC and the Treasury in particular, with control over the design of the overall system (including market support and electricity network). In practical terms, however, substantial areas of energy policy are devolved or under the control of the various national administrations. Regarding the formal distribution of powers, energy policy is only fully devolved to Northern Ireland. Under the Scottish Executive, devolved energy matters include the promotion of renewable energy (including importantly the power to set subsidy levels for renewable technologies under the Renewables Obligation Scotland only) and energy efficiency, consents for new electricity generating plant and transmission lines, planning and building regulations, environmental regulation, climate change, fuel poverty and transport (Scottish Government, 2009). The Welsh Assembly has the fewest powers, primarily concentrated on planning policy. In contrast to Scotland, Wales cannot adjust subsidy levels or decide on planning consents for major renewable generating developments.

---

[46] There is also a non-legislative framework of concordats between Government departments and the devolved institutions, under a Memorandum of Understanding (Parliament and Constitution Centre, 2003).

As such, since devolution in 1998, the various devolved administrations have increasingly adopted different strategies for renewable electricity (and energy). Although Scotland, Wales and Northern Ireland have set various (sub-national) renewable targets, the EU targets (and sectoral targets) are both negotiated and set at the UK overall level.[47] Therefore, devolution will have particular implications for renewable deployment.

3.3 The Non-Fossil Fuel Obligation

The Electricity Act 1989 under which the electricity sector was privatised put in place the legal basis for the UK's first 'renewables obligation' and renewable electricity target called the Non-Fossil Fuel Obligation (NFFO) (National Archives, 1989).[48] The NFFO mechanism was a centralised bidding system that ran from 1990 to 1998 (or 1999, in the case of Scotland). It required the regional electricity companies to purchase electricity from the nuclear power and renewable energy sectors. In order to select which renewable projects were to be supported, the government called for project developers to bid for contracts in an auction for a specified allocation of capacity within each technology band. In total there were seven bands: biomass, hydro, landfill gas, municipal and industrial waste, sewage gas, wave (only in the SRO) and wind. Successful bids depended on the projects' price per amount of energy generated and the cheapest proposals were selected first until the capacity allocation for each technology band was used up.

[47] This does not subtract from the importance of the contributions of the devolved administrations.

[48] Section 32 contained the provisions for the NFFO and Section 33 contains provisions for the Fossil Fuel Levy (FFL), the mechanism by which the Regional Electricity Companies or RECs (a number of which were formerly Public Electricity Suppliers) (National Archives, 1989). The NFFO actually refers to a collection of orders requiring the electricity distribution network operators in England and Wales to purchase electricity from nuclear power and renewable energy. Similar mechanisms operated in Scotland (the Scottish Renewable Orders: SRO) and Northern Ireland (the Northern Ireland Non-Fossil Fuel Obligation: NI-NFFO) (OFGEM, 2011a). There were five rounds made in England and Wales (1990, 1991, 1993, 1997 and 1998) and three rounds in Scotland (1994, 1997 and 1999). Unless specifically mentioned otherwise, the term NFFO will be used to include the three mechanisms.

The NFFO was primarily set up as a means to subsidise nuclear generation which had proved too difficult to privatise at that time. The inclusion of renewables into the definition of '*non-fossil fuels*' meant that it was effectively bundled with nuclear power (see also chapter 4.2). This resulted in renewables being vulnerable to EU limitations under the EU Competition Directive (85/413/EEC): as a government financial subsidy for non-fossil fuels, this led to the sanctioning for support offered under the NFFO mechanism for only 8 years (until 1998) (Europa, 2012a). The short-term contract nature of the initial mechanism had a number of fundamental effects for renewable deployment: given the high capital up-front costs of the various renewable electricity technologies (RETs) and the concomitant payback period required, it severely limited the amount of time a contracted project could expect to get financial help, thus increasing the developers risk and limited available funding for new projects (Mitchell, 1995).

The competitive nature of the NFFO also impacted on the success of the mechanism (Mitchell and Connor, 2004). As a market-based mechanism, formulated during the most radical change to the management and ownership of the power sector (privatisation and liberalisation), the then Department of Trade and Industry (DTI) wanted to reduce the average price per kWh of each bidding round to signify success. This led to many bids being too competitive (too low) and the contracted projects not being built. Also, unrealistically low bids could be entered in-order to thwart more realistic (serious) competitors. Again this problem increased due to the absence of a penalty mechanism for the failure to take up a contract (Wood and Dow, 2011). The bidding nature of the NFFO also had adverse affects. Developers did not know when bids would occur (irregular and unannounced timetable: 1990, 1991, 1995, 1997 and 1998 and 1994, 1997 and 1998 in Scotland), what capacity targets would be set for each technology band for each round and what other bid prices would be. This further increased the risk to developers.

An additional outcome of the design of the NFFO mechanism was that, particularly in the case of onshore wind power, developers had to utilise the best resource sites in order to maximise their financial returns. Areas of particularly high wind resource are typically located in upland and coastal regions, favoured for the lack of development and close to populated areas, respectively. Compounded by the problem that successful developers offered contracts in the bidding process generally applied for planning permission and started construction more or less all at the same time (hastened by the 8 year cap on subsidy revenues and the focus on lowest costs), this led to the view of a '*wind rush*' leading to a backlash from the population concerned by the effects this could have on the environment (Edge, 2006; Wood and Dow, 2011).[49] In addition, small-scale and community and community projects were basically excluded due to costs being typically more expensive in contrast to larger projects, leading to the marginalisation of local concerns and involvement. In turn, this exacerbated the problems of planning permission from the local planning authorities.

This was the context in which the first two NFFO rounds (NFFO1 and NFFO2) occurred. The NFFO was reformed in 1993 in an attempt to address some of these failures. As the timetable for the privatisation of the nuclear industry kept slipping, the UK government made the decision to separate renewables from nuclear power. The reform of the mechanism extended the contract duration from 8 to 15 years, with yet another change in the application procedure: for NFFO round 3, contractors were offered the bidding price (as opposed to a strike price as offered in NFFO2) (Mitchell, 1995). The reforms also introduced a grace period (initially 4 years in 1994, thereafter rising to five years) where developers could apply for planning consent and grid connection in addition to cancelling a project if real cost reductions in technology, operation and maintenance failed to meet expected reductions. The UK government also clarified the policy objectives regarding renewable energy. Such objectives included: stimulating the full economic exploitation of UK alternative energy resources; to establish and develop options for the future; to encourage UK industry to develop capabilities for domestic and export markets; and to acknowledge the barriers to increased installation (Department of Energy, 1988; Department of Trade and Industry, 1994; Wood and Dow, 2011).

[49] It can be argued that this was the origins of what has been termed the '*Not In My BackYard*' or NIMBY movement.

Critically, the inclusion of two clauses were introduced to NFFO3 contracts: the '*levy out*' clauses whereby RECs would not be required to make up the shortfall between the pool and premium price; and the '*supply out*' clause which essentially set a cap (25 per cent) on the amount of renewable electricity generation the RECs were obligated to take (Mitchell, 1995). Regarding the technology bands, although two new sub-bands were introduced (biomass gasification and small-scale wind), sewage gas was excluded and more costly options including solar photovoltaics, offshore wind, wave (except SRO3, see above), tidal stream and geothermal were effectively forced out through exemption from the mechanism (Komor, 2004). In addition, the government announced in 1993 that there would be 3 more rounds but not when they would actually take place.[50]

However, the damage was already done to some extent. Excessive policy change and the uncertainty of when bidding rounds would occur and which technologies would be included in addition to target capacity uncertainty exacerbated the stop-go nature of the mechanism whilst excessive competition adversely affected the number of contracted projects being commissioned (Sawin, 2004). This was particularly the case of the hiatus between NFFO2 and NFFO3 (2 years) and NFFO3 and 4 (4 years). In addition, the vast majority of the subsidy specified by the 1989 Electricity Act (the Fossil Fuel Levy which was placed on all sales of electricity from fossil fuel generators) went to nuclear.[51] Planning permission problems increased with local planning authorities receiving no real guidance with regard to renewable projects. This was further exacerbated by the complexity of the NFFO process that was only really accessible to professional developers and financiers, local communities and small independent companies were effectively shut out of the mechanism. This resulted in increased risk and thus also costs to developers (Mitchell, 1995; Mitchell and Connor, 2004). The excessive fiscal constraints (and the initial short-term contracts of NFFO1 and NFFO2) of the market-based NFFO resulted in UK manufacturers being unable to meet demand and developers going abroad for equipment. Despite clarification of the government's policy objectives

[50] NFFO support for anaerobic digestion, energy crops and forestry waste did not occur until NFFO4.

[51] In 1990-91, 0.5% (£6 million out of a total of £1,175 million) went to renewables, increasing to 8% (£96 million out of £1,204 million available) in 1994-95 (Connor, 2003).

for renewable energy, the NFFO failed to encourage UK industry to develop capabilities for both domestic and export markets.

Table 3.1 (page 73) shows that only 30 per cent (1,109MW) of total contracted capacity actually resulted in commissioned (operational) projects. Deployment under the NFFO was primarily driven by landfill gas (236MW or 43 per cent of total deployment), municipal/industrial waste (236MW or 21 per cent) and onshore wind (220MW or 20 per cent). For wind power, less than 20% of a total of 1,153.7 MW DNC awarded contracts were built, representing the loss of a considerable market for this technology. In general the NFFO

> "... r*esulted in one of the lowest levels of RES-E in the EU... in one of the best-endowed countries with regard to wind resource available.*" (Lauber, 2004: 1409).

Overall, by 2002, renewables supplied approximately 3% of electricity, a slight improvement on the level when the NFFO was implemented, which was just under 2% (Smith and Watson, 2002).

One of the most successful elements of the NFFO was that it permitted some insights into the real pricing of renewables and did succeed in providing a pressure to keep bid prices as low as possible. There are a number of alternative reasons for price drop, however, not directly related to the way the mechanism operated: the largest drop in prices per kWh occurred between rounds 2 and 3, coincident with the increasing length of contracts and the introduction of the grace period; economies of scale; and increasing industry experience and technological advances driven by the existence of larger markets.

It is clear that the NFFO underperformed, not only against the target (by almost 60 per cent) but also against the set policy objectives as stated by the government as early as 1988: significantly low deployment rates; technology options concentrated on only three technologies (with only real success for landfill gas) and the exclusion of other

Table 3.1 The capacity of contracted projects contra commissioned projects for the NFFO by 2004 (Edge, 2006).

	Contracted Projects		Commissioned Projects		
Technology	Number	Capacity	Number	Capacity	As a %
Biomass	32	256	9	10	4
Hydro	146	95	68	47	49
Landfill gas	329	700	226	475	68
Municipal/Industrial Waste	90	1,398	20	236	17
Sewage gas	31	34	24	25	74
Wave	3	2	1	0.2	0.1
Wind	302	1,154	93	220	19
Total	**933**	**3,639**	**441**	**1,109**	**30**

Note: Capacity in MW Declared Network Capacity (DNC). The data includes all relevant projects for the NFFO, NI-NFFO and the SRO.

RETs; a failure to develop UK renewable industrial capabilities and supply chain; and an inability to address all but the most obvious barriers to deployment, both internal and external. It could be argued that where such barriers were addressed, this was the result of opportunism (for example, extending the contract period due to the inability to privatise the nuclear sector). Indeed, there was a complete lack of consideration in the UK approach to RES-E deployment from a systemic approach, despite an early awareness of the interaction between the competitive bidding system and planning and public participation and engagement as argued by Mitchell (1995).

3.4 The Renewables Obligation

In contrast to previous years where government support for renewables was largely opportunistic, the momentum to increase the deployment of renewable energy and renewable electricity in particular increased from the latter part of the 1990s onwards. At the international level, the UK signed up to the Kyoto Protocol, adopted in December 1997, requiring a reduction in greenhouse gas emissions (GHG) of 12.5% by 2012 against the baseline of 1990 emission levels (United Nations Framework Convention on Climate Change [UNFCCC], 2007). Just one month prior to the signing of the Protocol, the European Commission (EC) published a White Paper for a Community Strategy and Action Plan titled '*Energy for the Future: Renewable Sources of Energy*' (EC, 1997). The 1997 White Paper set out to boost renewable deployment within the EU by proposing a target of 12 per cent gross inland energy consumption from renewables for the EU-15 by 2010, of which RES-E would represent 22.1 per cent.[52] This led to the 2001 European Union Directive '*2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market*' which provided the first EU-wide renewable electricity target: the national indicative target for the UK was 10 per cent RES-E generation by 2010 (Eur-Lex, 2001).[53]

---

[52] This represented a doubling of gross inland energy consumption from renewables at the EU-15 level (from 6% in 1997). From an individual Member State level, the figures ranged from 0.7% (UK) to 25.4% (Sweden). In 1995, the most recent year for RES-E data, at the EU-15 level 14.3% (or 337TWh) was produced (EC, 1997). Again, at the individual Member State, RES-E deployment ranged in 1997 from 1.1% (Malta) to 70% (Austria). For the UK, this figure was 1.7% (Eur-Lex, 2001).

[53] Although failure to attain the target would not entail a breach of the 2001 Directive, there are possible enforcement mechanisms: where Member States set targets too low (below reference figures set out in

In the same year as the Kyoto Protocol and the publication of the EC White Paper, the Labour Party won the general election. Although the then incoming government maintained the current NFFO, with NFFO4 and 5 (and SRO3 and 4), the government decided as early as 1999 to change the mechanism (Mitchell and Connor, 2004). By dissolving the regional electricity companies (RECs) into distribution and supply companies, the Utilities Act 2000 removed the legal basis of the NFFO and paved the way for a new RES-E subsidy mechanism: the Renewables Obligation (National Archives, 2000).[54] Importantly, the UK would have to increase RES-E generation output from around 3 per cent to 10.4 per cent in eight years. In addition to attempting to meet the key policy objectives which remained essentially the same as those set under the NFFO, the replacement mechanism would also have to counter the defects of the previous regime.

The RO commenced operation in April 2002. As with the NFFO, in practice the term 'Renewables Obligation' refers to three complementary Obligations: one covering England and Wales, and one each for Scotland (Renewables Obligation Scotland: ROS) and Northern Ireland (Northern Ireland Renewables Obligation: NIRO) (OFGEM, 2011b).[55] Under the RO, licensed electricity suppliers are mandated or obliged to supply a set proportion of their sales from renewable generation. In 2002, the first year of operation, this target (as a percentage) started at 3 per cent and was initially set to rise to 10.4 per cent by 2010-11. The obligation was then set to remain at this level until 2027. In order to successfully comply with the Obligation, the suppliers have to obtain Renewable Obligation Certificates (ROCs), a tradable instrument that qualifying generators are awarded in proportion to their output. One ROC is equal to one-

---

the Directive without explanation) or fail to take appropriate steps including failing to set a 2010 RES-E target or where measures implemented would clearly be incapable of achieving the target (Johnston, 2010).

[54] Sections 62 to 67 of the UK Utilities Act 2000 put in place the legal basis for the Renewables Obligation Order (National Archives, 2000).

[55] Unless specifically mentioned otherwise, the term RO will be used to include the three mechanisms. The particulars of the RO at the time of commencement are set out in '*The Renewables Obligation Order 2002*' (National Archives, 2002).

megawatt hour (MWh). This results in the guarantee of two revenue streams for renewable generators: the income from the tradable ROC sales and power (electricity) output sold at market prices.[56]

Compliance is ensured by the buy-out price. If a supplier is unable or unwilling to obtain its obligated requirements for ROCs, it has to pay a buy-out price. This was set at £30/MWh in 2002/03 and rises annually at the rate of inflation. A novel feature of the RO is that the funds raised from the payment of the buy-out payment are recycled. In other words, they are redistributed pro-rata to those suppliers (the 'competitors' of those suppliers that failed for whatever reason to meet the obligation) that successfully met their obligation and thus obtained the required amount of ROCs. The secondary – and intention of the government – effect of the recycling mechanism is to effectively cap the cost of the RO. The closer the obligation target is to being achieved, the lower the ROC price will be. This acts to disincentive investors to build too much capacity and thus threaten the return on generating plant already built.

From its inception, the Renewables Obligation was deliberately designed to be a more market-based mechanism than the previous Non-Fossil Fuel Obligation.[57] The clear intention of the RO, in contrast to the NFFO, was to force renewable developers to participate in the electricity market (Mitchell and Connor, 2004). This was stated clearly before the implementation of the mechanism in '*The Renewables Obligation Statutory Consultation*' document (National Archives, 1999: 7):

---

[56] There is also the Climate Change Levy (CCL) – a tax delivered on most energy users with the exception of domestic and transport sectors and equals 0.456 pence/kWh for 2008-09 in line with inflation (Climate Change Levy, 2008) – and the recycled buy-out premium.

[57] Indeed, the (then) incoming New Labour Government had indicated that it accepted the broad tenets of what is termed the '*Lawsonian Paradigm*' (whereby privatisation and competition were viewed as the main pillars of UK energy policy, and in most other areas of the economy) although such a position was also to be tempered by a more interventionist approach to energy policy and its objectives (Helm, 2003; Rutledge, 2007). In particular, Rutledge (2007: 1) highlights the point that "*... New Labour and its advisors have come to espouse a particularly 'fundamentalist' view of the role of 'competitive markets' in achieving energy policy objectives.*"

> "*The RO moves away from the NFFO approach and reflects the Government's belief that the way forward is to create the market conditions for a thriving, dynamically competitive renewables industry.*"

The primary reasons why the RO is viewed as a more market-based mechanism than the NFFO, particularly for developers/generators is that it leaves

> "*… the price and technology choice (there are no requirements on what type of RES-E to be purchased) to the market whilst the Government sets the quantity (the Obligation level or target) to be achieved.*" (Wood and Dow, 2011: 2230).

In contrast to the NFFO there was no must-take (or priority access) contract for renewable electricity or indeed specified contract length due to the dissolution of the former Regional Electricity Companies (Mitchell and Connor, 2004). Another result of the market-based nature of the RO is that generators did not have any real knowledge of what they will be paid for each contract due to ROC and wholesale electricity price fluctuations as both revenue streams depend on supply and demand (Wood and Dow, 2011). This led to the RO being a high-risk mechanism.[58] It is difficult to obtain finance in large part due to price risk and the uncertainty that resulted from this: generators lacked the knowledge of what they would be paid beyond typically short-term contracts (no must-take contracts); the threat of supplier default (for example, the supplier TXU Europe failed with the result that the buy-out fund was less than expected); and the trading of ROCs was limited due to the fact that as most already large-scale generating companies became vertically re-integrated through mergers and acquisitions, selling to their in-house suppliers increased (Lipp, 2007). A further deliberate design feature of the RO was the introduction of volume risk to avoid over-performing with regard to the 2010 target: the greater the progress towards the Obligation target the more the subsidy value (ROCs and the buy-out premium) decreased as demand dropped. This resulted effectively in creating an incentive not to meet the target. Two factors in particular contributed to this. The concentration of market share in terms of both supply and generation assets within the '*Big Six*' vertically integrated electricity

---

[58] By removing the must-take (or priority access) contracts placed on the former RECs – thought to separate renewable generators too much from the reality of the market – government policy removed the key reason why the NFFO was perceived as a low-risk environment.

companies and the dragging-out of the target process by the UK government (see below) (Friends of the Earth [FOE], 2011).

The RO was specifically designed to be technologically blind because the DTI (2001: 3).

> "[Believed] *that a banded obligation would segment the market unnecessarily, and would lead to the Government dictating the relative importance of each technology… that it is no longer the Government's job to pick winners or to introduce artificial distortions in the marketplace*"

The creation of a single market for all the renewable electricity technologies, however, combined with an emphasis on costs and thus increasing market competition resulted in the RO primarily benefiting cheaper, more market-ready technologies. This meant primarily on-shore wind, landfill gas and co-firing, with more expensive technologies effectively being priced out of the mechanism. These 'excluded' technologies included offshore wind, wave power, tidal stream power, energy crops and solar photovoltaics (Foxon *et al*., 2005).

This was despite the fact that a number of these RETs, the marine renewables and offshore wind in particular had already been singled out by government as having the potential to deploy at significant scale. As early as 2000, the Crown Estate (CE) had commenced the first round for offshore wind leasing agreements with further rounds planned for 2003 and beyond (Crown Estate, 2012a).[59] In addition, just one year after the implementation of the RO, the 2003 Energy White Paper '*Our energy future – creating a low carbon economy*' stated that offshore wind was

---

[59] The CE is a property portfolio owned by the Crown and governed by an Act of Parliament (Crown Estate Act 1961) and managed by an independent organisation headed by the Crown Estate Commissioners. Surplus revenue is paid annually to HM treasury (Crown Estate, 2012b; UK Government, 1961). The Crown Estate (CE) owns approximately 55 per cent of the UK's foreshore and virtually the UK's entire seabed from mean low water to the edge of the continental shelf and the 200 nautical mile limit (the exclusive economic zone). As such, the Crown Estate plays a major role in the development of the UK offshore wind, wave and tidal stream energy industry. In particular, it leases areas of the seabed for commercial development of offshore renewable electricity supply technologies. Since 2000, there have been five rounds (a tender-based process) of offshore wind which have increased in scale and technical complexity as the industry has developed (Wood and Taylor, 2012).

> "*... about to take off... We have more wind off our coasts than anywhere else in Europe... we should be able to expect offshore windfarms to make a strong contribution to our carbon aims.*" (DTI, 2003: 54).

The primary result of this has been to stifle rather than stimulate innovation and the necessary introduction of capital subsidies for certain technologies to combat the RO price cap that effectively excludes them. With the risk that a number of RETs and offshore wind in particular were being made permanently uncompetitive through a lack of market access, the government introduced a capital grants programme in order to increase momentum for deployment (DTI, 2003). A substantial proportion of the capital grants (over the period 2002-05) were allocated to offshore wind, highlighting the fact that one of the UK Government's preferred options could not be supported by the financial subsidy mechanism alone.

So far, the discussion here has focused on the internal failures of the Renewables Obligation. There are also a number of external failures issues that have proven to be significant barriers to the deployment of renewables in the UK. Part 4 of the Utilities Act 2000 established the New Electricity Trading Arrangements (NETA) in 2001 to replace the British electricity pool that had been set up with the privatisation of the electricity sector in 1989 (National Archives, 2000). The reasoning behind the introduction of NETA was to extend competition in the wholesale market and contribute to a more competitive market amongst electricity generators and suppliers. As such, NETA created a new regulatory framework that governed the way in which electricity was sold with the jurisdiction of the regime encompassing England and Wales. Although the regime remained largely unchanged, the geographical scope of NETA was extended in 2005 to include Scotland with NETA becoming the British Electricity Trading and Transmission Arrangements (BETTA).[60]

In summary, BETTA was designed to achieve the following objectives: to meet the needs of customers with respect to price, choice, quality and security of supply; enable

---

[60] Part 3 of the Energy Act 2004 set out the legal basis for the BETTA (National Archives, 2004). This occurred despite resistance from many renewable generators and support groups (Komor, 2004).

demand to be met efficiently and economically; enable costs and risks to be shared efficiently; promote competition in electricity markets; avoid discrimination against particular energy sources; and are compatible with government policies to achieve diverse, sustainable supplies of energy at competitive prices and with wider government policy, including on environmental and social issues (OFGEM, 1999). However, BETTA was not designed to promote the use of electricity from renewable sources: it has an in-built preference for flexible and predictable sources of generation, leaving intermittent sources at a relative cost disadvantage (Smith and Watson, 2002). It is also a complex mechanism that imposes high costs on small generators (in terms of membership, personnel and information transfer) and places a high premium on flexibility and penalises intermittent and unreliable generation (NAO, 2003). An important point here is that whether or not the costs incurred by intermittent (less predictable) generators, namely renewables, is disproportionate, NETA/BETTA has imposed new costs which will disproportionately impact on small-scale renewable generators in contrast to large-scale companies. In addition, small-scale renewable generators typically lacking a diverse portfolio of generation assets and/or do not act as electricity suppliers can not mitigate the impact of BETTA via self-balancing.[61] As a result, many small generators avoid it and sell via a supplier. However, most grid supply areas (the distribution area generators sell into to avoid losing the distributed benefits of RES-E) only have one supplier thus constraining selling options. These risks are compounded by the fact that renewable energy is generally more expensive than conventional thermal generation (coal, gas and nuclear), does not taken into account external costs (apart from the CCL component) with its focus on the marginal cost of green technology (Lauber, 2004) and is typically very capital intensive and needs this capital upfront.

Problems with the planning system originated early on in the operation of the previous subsidy mechanism. However, planning remained a contiguous barrier to renewable deployment under the RO. There were concerns that the planning system was too slow

[61] Self-balancing allows a company, typically vertically-reintegrated with both generation and supply facilities, to balance electricity supply through the control of intermittent and non-intermittent generation owned by the company.

in granting consent, administratively burdensome in terms of complexity and cost, lead to uncertain results and failed to take into account national (and international) priorities set by legally-binding renewable and climate change targets, particularly at the local level. In addition, the planning system was often been perceived as frustrating local and central government's key political objectives (British Wind Energy Association [BWEA; now Renewables UK], 2009; Innovation, Universities, Science and Skills Committee, 2008a, b; Jones and Eiser, 2010; National Audit Office [NAO], 2008; 2010; Scottish Government, 2005). Despite the various national administrations introducing new renewable-specific guidelines for local planning authorities, there was no attempt to introduce significant reforms to the onshore planning system until immediately prior to the reform of the Renewables Obligation.[62] Major reforms did not take place until 2008 (the Planning Act 2008 in England) and although the Scotland Planning (Etc) Act was established in 2006 a significant number of key provisions did not come into force until 2009 (Wood, 2010; Wood and Dow, 2011).

This can be seen by looking at planning statistics for onshore wind, one of the main RETs to have evidenced significant growth under the RO mechanism.[63] In 2007, the average time taken from submission of a planning application to determination was over 41 months for >50MW onshore wind farms and over 16 months for <50MW.[64] In comparison, by 2012 this had fallen to just 30 months and over 11 months, respectively. At the same time, however, approval rates either remained approximately the same as

[62] The UK planning system, however, is not monolithic. Planning is largely a devolved issue and the Devolved Administrations set policy in their respective nations. Devolution has led to a divergence in the planning systems which operate within the various national administrations. Significantly, there are different levels of devolved responsibilities due to the fact that the UK system of devolution is asymmetric. Regarding planning specifically, this was devolved or placed under the legislative competence of the Scottish Parliament, the Northern Ireland Executive and the Welsh Assembly (Parliament and Constitution Centre, 2003).

[63] These statistics are taken from the Renewable Energy Planning Database (REPD) (DECC, 2012). See chapter seven, section 7.2 for a more detailed analysis of planning data.

[64] Onshore energy generation infrastructure with an installed capacity greater than 50MW typically lies under the control of central government whilst developments with an installed capacity lower than this fall under local authority control. Prior to 2011, hydro power was the key exception to this rule: the capacity cut-off point is 1MW of installed capacity. This is the same across the UK. The situation is different for offshore wind: in England the cut-off point is 100MW. For Scotland, it is 1MW.

that seen in 2012 for >50MW projects or was significantly higher for <50MW projects: 74 per cent compared to 48 per cent at the UK level for the years 2007 and 2012, respectively (see chapter eight section 8.2 for a more detailed account).

By design, the Renewables Obligation has resulted in a focus on onshore wind power. Onshore wind was and continues to be one of the most technologically mature and market-ready renewable technologies that can be deployed at the large-scale. Although this is a characteristic that onshore wind shares with other RETs, including offshore wind, wave power, tidal stream power and solar photovoltaics, these options were either not technologically mature and/or market ready. As with the NFFO, in order to maximise revenues (both subsidy and electricity) developers focused on those sites with the highest wind resource. Invariably, a number of locations were either close to where people lived or in areas that people favoured because there was a lack or absence of development. However, as the number of wind farms increased, along with the number of individual turbines per development and the size of the turbines, so did the pressure on the landscape. The particular characteristic of onshore wind turbines (tall, sited to obtain optimum wind availability and thus unable to be screened) aggravated the issues, with regard to both planning and public opinion.

This has been further exacerbated for two key reasons: because of the increased price risk and resultant difficulties and extra cost in obtaining finance and the complex nature of the mechanism itself, the RO militates against small, independent and community-based projects that could alleviate planning and acceptance barriers at least to some extent by promoting renewable projects from the bottom-up, by actively informing and involving the local population where such projects would be developed and the public in general (Mitchell and Connor, 2004; Lipp, 2007). By design, then, the RO is a stronger supporter of large, usually multi-national companies with substantial assets that have vertically re-integrated – thus they can take on the RO risks themselves. The absence of a bottom-up approach led to a lack of public acceptance of renewable projects (mainly onshore wind – a major contributor to renewable deployment in the UK) and resulted in a high rate of renewable projects failing to get planning permission.

The UK's approach to transmission and distribution issues also highlights policy inconsistency and contradiction. Despite the strong emphasis in the 2001 EU Renewables Directive for Member States to reduce regulatory and non-regulatory barriers to renewable energy (this includes planning permission and grid issues), there is no special treatment of renewable energy projects within current UK regulatory frameworks, and the rules that do apply to renewable generation projects apply to all other generation projects. Further, Scott (2007: ix) points out that

> "*GB* [Great Britain] *appears generally reluctant in its promotion of renewable energy via grid related practices, achieving compliance only with mandatory articles and questionably in two cases – 'non-discrimination of renewable energy in peripheral areas' and 'guaranteed transmission (and distribution) access.*"

Although the UK does provide one of the most competitive connection charging regimes in Europe with regard to physical grid connection charges (a super-shallow approach), it does not provide priority access for renewable projects, priority despatch of renewable energy, or implement a must-take policy. Under existing rules, thermal generators are effectively given preference over renewables in the connection queue, in particular when demand for network capacity exceeds supply (as is currently the case), and the '*first come, first served*' approach compounds the problem by meaning renewable generators without planning permission or finance can occupy a place in the queue ahead of those who are ready. This has resulted in substantial delays (10 years or more) and is of concern given the 17 GW of renewable generation currently in the queue for connection to the transmission network (OFGEM, 2008). Critically, there is very little forward or strategic planning for renewables to be connected to the grid with regard to where electricity network reinforcement and/or upgrade is required. In turn, this is aggravated by the fact that onshore wind developments are typically deployed in areas lacking in either physical transmission infrastructure or have the capacity available to connect new generation infrastructure.

UK renewable energy policy was still characterised by uncertainty, constant adjustments and significant change. In addition to the mechanism transition (from the NFFO to the RO), with the four year hiatus in government support resulting in virtually no new deployment, there have been a number of examples of policy risk. Although optimistic and pro-renewables, the 2003 Energy White Paper increased uncertainty over the future of the RO only one year after its implementation by proposing a review of the mechanism (despite the RO having been intended to run until 2027) and by stating that carbon trading would be the main policy going forward (DTI, 2003). In addition, the White Paper dragged out the target process by failing to set new targets despite setting out the expectation that future targets would occur.[65]

Although some of these failures are new or more significant to the RO (NETA/BETTA; price risk; volume risk; the scale of electricity transmission work required), many of the failures were known from the NFFO (focus on low costs; excessive focus on competition; planning; and policy risk). The low level of deployment and the lack of RET diversity highlights the point that lessons had not been learned by government despite almost two decades of operational experience (Wood and Dow, 2011). With regard to the policy aims of the RO, then, a low level of renewables deployment focused particularly on onshore wind, has failed to meet the targets, not reduced CO^2 emissions as projected, failed to increase security and diversity of supply issues and hence alleviate security of supply concerns. And like the NFFO, the RO has failed to encourage UK industry to develop capabilities for both domestic and export markets and thus stimulate the full economic exploitation of alternative energy resources in the UK due to the emphasis on achieving reductions in the price paid for renewable energy precludes both many RETs and entry by smaller producers (Mitchell *et al*., 2006).

When the actual RES-E generation output obtained under the RO is examined (Table 3.2, page 85), it is obvious that the RO is not working as intended: despite output (and deployment) having increased significantly in comparison to the NFFO, the RO has consistently under-performed with regard to the Obligation targets. The 2010 RES-E target was missed by a third, and has not been achieved as of the end of 2011. Although

---

[65] The RES-E sectoral target of 15.4% by 2015 was only set out in '*The Renewables Obligation Order 2005*' (National Archives, 2005). Even then, the target was merely aspirational. The 2020 renewable target (including the RES-E sectoral target) was only implemented in 2009 (Europa, 2009).

Table 3.2 RES-E generation output as a percentage under the Renewables Obligation

	NFFO		RO							rRO	
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Target	-	-	3.0	4.3	4.9	5.5	6.7	7.9	9.1	10.4	[1]
Output	1.6	1.9	2.4	3.6	4.2	4.5	5.0	5.5	6.6	6.8	9.4

SOURCE: Department of Business, Enterprise and Regulatory Reform [BERR], 2008; DECC, 2010; DECC, 2012.

Note: [1] There is no target between 2010 (10.4%) and 2020 (30-35%).

2010/11 exhibited the largest annual increase in output (under the rRO), generation output overall needs to more than treble in eight years. In addition, Wood and Dow (2011: 2241-42) point out the key deficiencies of the Renewables Obligation mechanism:

> "*An examination of the internal and external failures of the NFFO and the RO reveal that despite the differences between the two support mechanisms, both share a number of internal and external failures... In particular, they created high levels of risk and uncertainty for investors/developers, due to an excessive emphasis on cost reduction, the unknown price of electricity and ROC values (for the RO), leading to the preferential uptake of the more mature least-cost technologies (e.g. primarily onshore wind) at the expense of increasing the deployment of other more expensive technologies that, although not fully mature in market terms, could have been developed with additional support. In addition, external failures were either not sufficiently addressed (planning, grid issues: both exacerbated by the focus on onshore wind), introduced (BETTA) or continued (policy uncertainty). These failures increased the risks, costs and uncertainty to renewable generators/ investors and seriously limited the level of deployment that could have otherwise been attained, resulting in the added failure to meet stated UK renewable energy policy goals, including consistently under-performing with regard to renewable energy targets, developing the renewables sector (for domestic and export markets) with resultant employment growth, reducing carbon dioxide emissions and increasing diversity/security of energy supplies.*"

This is reminiscent of the state that occurred when the RO replaced the NFFO, indicating a failure of the Government to learn from past experiences at the NFFO/RO mechanism transition. Figure 3.1 (page 87) highlights this by portraying the key internal and external failures of both mechanisms. What is notable about Figure 3.1 is that, despite the obvious differences, it reveals a high degree of similarity between the two mechanisms with regard to both internal and external failures: finite and limited duration of subsidies due to limited mechanism lifespan, excessive focus on competition and low costs, mechanism uncertainty, unresolved planning and electricity grid network issues and policy uncertainty/excessive change. Those areas in which the mechanisms differ are also interesting. This is because it reveals that the RO introduced three new failures (two internal and one external) in contrast to removing only one internal failure: subsidy bundling (renewables and nuclear power were included under

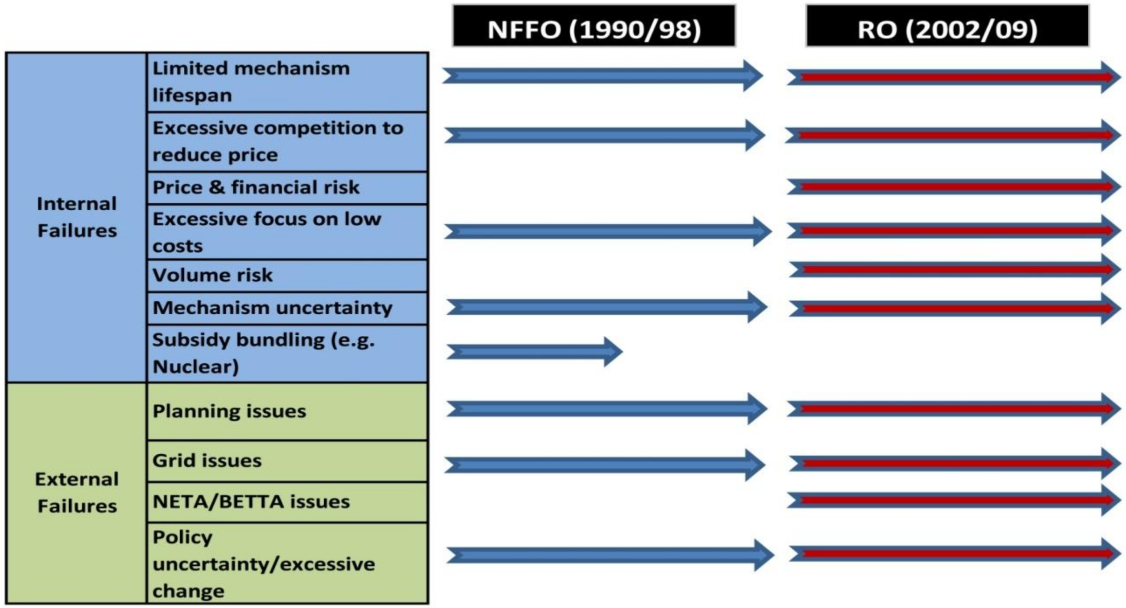


Figure 3.1 The key internal and external failures of the NFFO and RO (1990-2009)

the NFFO from 1990 to 1998 with the result that the vast majority of the subsidy was allocated to nuclear power). Importantly, the RO increased price/financial risk and policy risk, resulting in making it difficult to obtain finance. In addition, volume risk was introduced along with the NETA/BETTA. Despite the warning signs early on which government largely ignored or delayed addressing, a major implication of this is that it would lead to the prospect for more changes to the policy, legislative and regulatory landscape.

References

British Wind Energy Association [BWEA: now Renewables UK], 2009. Wind Energy in the UK: State of the Industry Report – October 2009. BWEA, London.

Connor, P. 2003. UK renewable energy policy: a review. Renewable and Sustainable Energy Review 7(2003): 65-82.

Crown Estate [CE], 2012a. Our portfolio [online] Available from http://www.thecrownestate.co.uk/energy-infrastructure/offshore-wind-energy/our-portfolio/

Crown Estate [CE], 2012b. The Crown Estate: What we do [online] Available from http://www.thecrownestate.co.uk/

Department of Business, Enterprise and Regulatory Reform [BERR], 2008. Digest of United Kingdom Energy Statistics: 2008 [online] Available from /http://www. berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html.

Department of Energy, 1988. Energy Paper 55: Renewable Energy in the UK: The Way Forward. HMSO.

Department of Energy and Climate Change (DECC), 2009. UK low Carbon Transition Plan: National strategy for climate and energy [online] Available from http://www.decc.gov.uk/publications/basket.aspx?FilePath=White+Papers%2fUK+Low+Carbon+Transition+Plan+WP09%2f1_20090724153238_e_%40%40_lowcarbontransitionplan.pdf&filetype=4#basket

Department of Energy and Climate Change, 2010. Statistical Press Release — Energy Statistics 2010/072 [online] Available from /http://www.decc.gov. uk/en/content/cms/news/pn10_072/pn10_072.aspx

Department of Energy and Climate Change [DECC], 2011. Implementing the Climate Change Act 2008: The Government's proposal for setting the fourth carbon budget – Policy Statement – May 2011 [online] Available from http://www.decc.gov.uk/publications/basket.aspx?filetype=4&filepath=What+we+do%2fA+low+carbon+UK%2fCarbon+budgets%2f1683-4th-carbon-budget-policy-statement.pdf&minwidth=true#basket

Department of Energy and Climate Change (DECC), 2012. Planning Database [online] Available from https://restats.decc.gov.uk/cms/planning-database/

Department for Environment Food and Rural Affairs, 2012. Large Combustion Plant Directive [online] Available from http://www.defra.gov.uk/industrial-emissions/eu-international/lcpd/

Department of Trade and Industry [DTI], 1994. Energy Paper 62: New and Renewable Energy: Future Prospects for the UK. HMSO.

Department of Trade and Industry (DTI), 2001. New and Renewable Energy – Prospects for the 21st Century: The Renewables Obligation Preliminary Consultation [online] Available from http://www.berr.gov.uk/files/file21097.pdf

Department of Trade and Industry (DTI), 2003. Energy White Paper: Our Energy Paper—Creating a Low Carbon Economy February 2003 [online] Available from /http://www.berr.gov.uk/files/file10719.pdfS

Edge, G. 2006. A Harsh Environment: The Non-Fossil Fuel Obligation and the UK Renewables Industry, in K. Mallon (ed), Renewable Energy Policy and Politics: A handbook for decision-making: 163-184. Earthscan.

Eur-Lex, 2001. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0077:EN:NOT

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Europa, 2012a. Competition: Legislation archive – Transparency of public undertakings [online] Available from http://ec.europa.eu/competition/state_aid/legislation/transparency_archive.html

Europa, 2012b. Overview: Liberalisation of the electricity and gas markets [online] Available from http://ec.europa.eu/competition/sectors/energy/overview_en.html

European Commission [EC], 1997. Communication from the Commission: Energy for the Future: Renewable Energy Sources – White Paper for a Community Strategy and Action Plan: COM(97)599 final (26/11/1997) [online] Available from http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf

Foxon, T.J., Gross, R., Chase, A., Howes, J., Arnall, A., Anderson, D., 2005. UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures. Energy Policy 33, 2123–2137

Friends of the Earth [FOE], 2011. Report: The Dirty Half Dozen – October 2011 [online] Available from http://www.foe.co.uk/resource/reports/dirty_half_dozen.pdf

Helm, D. 2007. The New Energy Paradigm. Oxford University Press: Oxford.

Helm, D. 2008. Energy, the State, and the Market: British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford

Helm, D., Kay, J. and Thompson, D. 1989. The Market for Energy. Clarendon Press: Oxford.

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008a. Renewable electricity generation technologies – Volume I – Fifth Report of Session 2007-08 – 11 June 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/cmdius.htm

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008b. Renewable electricity generation technologies – Government Response to the Committee's Fifth Report of Session 2007-08: Eight Special Report of Session 2007-08 – 8 October 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/1063/1063.pdf

Jones, C.R. and Eiser, R. 2010. Understanding 'local' opposition to wind development in the UK: How big is a backyard? Energy Policy 18(2010): 3106-3117.

Johnston, A. 2010. How binding are the EU's 'binding' renewables targets? A legal perspective – European Electricity Workshop (CEEPR/EPRG), Berlin, 15 July 2010 [online] Available from http://www.eprg.group.cam.ac.uk/wp-content/uploads/2010/08/Johnston.pdf

Komor, P. 2004. Renewable Energy Policy. The Diebold Institute for Public policy Studies

Lauber, V. 2004. REFIT and RPS: options for a harmonised Community framework. Energy Policy: 32: 1405-1414.

Legislation, 1998a. Scotland Act 1998 [online] Available from http://www.legislation.gov.uk/ukpga/1998/46/contents

Legislation, 1998b. Government of Wales Act 1998 [online] Available from http://www.legislation.gov.uk/ukpga/1998/38/pdfs/ukpga_19980038_en.pdf

Legislation, 1998c. Northern Ireland Act [online] Available from http://www.legislation.gov.uk/ukpga/1998/47/contents

Lipp, J. 2007. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. Energy Vol 35(2007): 5481-5495.

Mitchell, C. 1995. The renewables NFFO – A review. *Energy Policy* 23(12): 1077-1091.

Mitchell, C. 1998. Renewable Energy in the UK: policies for the future. CPRE.

Mitchell, C. and Connor, P. 2004. Renewable energy policy in the UK 1990-2003. Energy Policy 32(2004): 1935-1947.

Mitchell, C., Bauknecht, D. and Connor, P. 2006. Effectiveness through risk reduction: a comparison of the renewables obligation in England and Wales and the feed-in system in Germany. Energy Policy: 34(3): 297-305.

National Archives, 1986. Gas Act 1986 [online] Available from http://www.legislation.gov.uk/ukpga/1986/44/pdfs/ukpga_19860044_en.pdf

National Archives, 1989. Electricity Act 1989 [online] Available from http://www.legislation.gov.uk/ukpga/1989/29/contents

National Archives, 2000. Utilities Act 2000 [online] Available from http://www.legislation.gov.uk/ukpga/2000/27/pdfs/ukpga_20000027_en.pdf

National Archives, 2002. The Renewables Obligation Order 2002: Statutory Instrument 2002 No. 914 [online] Available from http://www.legislation.gov.uk/uksi/2002/914/pdfs/uksi_20020914_en.pdf

National Archives, 2004. Energy Act 2004 [online] Available from http://www.legislation.gov.uk/ukpga/2004/20/pdfs/ukpga_20040020_en.pdf

National Archives, 2005. The Renewables Obligation Order 2005: Statutory Instruments 2005 No.926 [online] Available from http://www.legislation.gov.uk/uksi/2005/926/pdfs/uksi_20050926_en.pdf

National Archives, 2008. Climate Change Act 2008 [online] Available from http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

National Audit Office [NAO], 2003. The New Electricity Trading Arrangements in England and Wales: Report by the Comptroller and Auditor General – HC 624nSession 2002-2003: 9 May 2003 [online] Available from http://www.nao.org.uk/wp-content/uploads/2003/05/0203624.pdf

National Audit Office [NAO], 2008. Renewable energy: Options for scrutiny – A Review by the National Audit Office – July 2008 [online] Available from http://www.nao.org.uk/publications/0708/renewable_energy_options.aspx

National Audit Office [NAO], 2012. Performance of Ofgem: Briefing for the House of Commons Energy and Climate Select Committee – October 2010 [online] Available from http://www.parliament.uk/documents/commons-committees/energy-and-climate-change/NAO%20Briefing%20for%20ECCC%20on%20Performance%20of%20Ofgem_P1%20(2).pdf

Office of Gas and Electricity Markets [OFGEM], 1999. The New Electricity Trading Arrangements – Volume 1: July 1999 [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/Policy/SmallrGens/CommArrg/MktAdmin/Documents1/4090-reta1_99.pdf

Office of the Gas and Electricity Markets (OFGEM), 2008. Connecting Renewable Generation [online] Available from http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=80&refer=Media/FactSheets

Office of Gas and Electricity Markets [OFGEM], 2011a. Non-Fossil Fuel Obligation / Scottish Renewable Obligation [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/NFFOSRO/Pages/NFFOSRO.aspx

Office of Gas and Electricity Markets [OFGEM], 2011b. Renewables Obligation – What is the Renewables Obligation (RO)? [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

Office of Gas and Electricity Markets [OFGEM], 2012a. About us [online] Available from http://www.ofgem.gov.uk/About%20us/Pages/AboutUsPage.aspx

Office of Gas and Electricity Markets [OFGEM], 2012b. Third Package [online] Available from http://www.ofgem.gov.uk/Europe/ThirdPackage/Pages/ThirdPackage.aspx

Oxford Energy Research Associates [OXERA], 2012.Agenda: Does Ofgem have a future? May 2012 [online] Available from http://www.oxera.com/Oxera/media/Oxera/downloads/Agenda/Agenda-8-Does-Ofgem-have-a-future.pdf?ext=.pdf

Parliament and Constitution Centre, 2003. An introduction to devolution in the UK – Research Paper 03/84: 17 November 2003 [online] Available from http://www.parliament.uk/documents/commons/lib/research/rp2003/rp03-084.pdf

Pearson, P. and Watson, J. UK Energy Policy 1980-2010: A history and lessons to be learnt – A review to mark 30 years of the Parliamentary Group for Energy Studies [online] Available from http://sro.sussex.ac.uk/38852/1/uk-energy-policy.pdf

Pollitt, M. 2008. The Future of Electricity (and Gas) Regulation in a Low-carbon Policy World [online] Available from http://www.ofgem.gov.uk/Networks/rpix20/Factsheets/Documents1/1a.pdf

Rutledge, I. 2007. New Labour, energy policy and 'competitive markets'. Cambridge Journal of Economics 2007 (31): 901-925

Sawin, J.L. 2004. Mainstreaming Renewable Energy in the 21st Century. Worldwatch Paper 169.

Scott, N.C. 2007. European Practices with grid connection, reinforcement, constraint and charging of renewable energy projects [online] Available from http://www.hie.co.uk/HIE-economic-reports-2007/EU-practices-grid-connection.pdf.

Scottish Government, 2005. White Paper on Planning – Modernising the Planning System [online] Available from http://www.scotland.gov.uk/Publications/2005/06/27113519/35231

Scottish Government, 2009. Energy – Taking forward our National Conversation [online] Available from http://www.scotland.gov.uk/Publications/2009/11/25093815/11

Scottish Government, 2011. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Smith, A. and Watson, J. 2002. The Renewables Obligation: Can it deliver? Tyndall Centre for Climate Change Research: Briefing Note 4 April 2002 [online] Available from http://www.tyndall.ac.uk/publications/briefing_notes/note04.shtml.

UK Government, 1961. Crown Estate Act 1961 [online] Available from http://www.legislation.gov.uk/ukpga/1961/55/pdfs/ukpga_19610055_en.pdf

United Nations Framework Convention on Climate Change [UNFCCC], 2007. Kyoto Protocol: Negotiating the Protocol [online] Available from http://unfccc.int/kyoto_protocol/items/2830.php [Accessed 10 February 2008].

Wilson, C. 2012. A history of the UK renewable energy programme, 1974-88: some social, political, and economic aspects. PhD thesis [online] Available from http://theses.gla.ac.uk/3121/

Wood, G. and Dow, S. 2011. What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy

Wood, G. and Taylor, A. 2012. Offshore Wind - A Position paper: A Report for the Offshore Renewables Institute – December 2012.

Part II
Renewable electricity, targets and technologies

Part II of the thesis sets out the context in which renewable energy in general and large-scale renewable electricity technologies in particular operate within the electricity and wider energy landscape. This establishes the frame of reference by which large-scale renewable electricity technologies will be interpreted in Part III of the thesis. Chapter four looks at how existing academic and political definitions of renewable energy are constructed, and what this means with regard to the meaning of the term renewable energy in terms of naturally renewing or replenishment and the level of greenhouse gas emissions produced by the various renewable electricity technologies. The second part of this chapter questions the arguments underlying why renewable electricity is perceived as special and therefore required.

Chapter five first establishes the critical role of renewable electricity to longer-term renewable and climate change (decarbonisation) objectives before investigating and comparing the economic, technical, resource, social and environmental attributes of the various renewable electricity technologies. This is carried out in order to develop an understanding of the options available for the individual technologies particularly with regard to their deployment within the overall electricity system. A particular theme of the first two chapters is to examine alternative large-scale low carbon technologies and compare them with renewable electricity technologies in order to highlight the latter technology group's options and attributes with regard to deployment.

Chapter six establishes the baseline contribution of renewable electricity in the UK and analyses the historical and current trends in renewable electricity deployment. The second part of this chapter determines the level of deployment required to meet the 2020 renewable electricity sectoral target. This is done in order to determine the deployment trajectories of the individual technologies and clarify their relative positions in terms of deployment. Further, this permits the identification of the amount of deployment required, and how that corresponds with regard to government assumptions about individual technology deployment particularly with regard to the 2020 sectoral target. This chapter also looks at deployment at the sub-national level with particular emphasis on Scotland.

Chapter Four
Renewable energy: definitions and contexts

4.1 Introduction

This chapter begins by exploring and unpacking the meaning of the term renewable energy with a specific focus on renewable electricity. Section 4.2 looks at the existing definitions for renewable energy and discusses the particular implications for the various large-scale renewable electricity technologies. This is important as the definition of what constitutes a renewable source of energy determines those technologies that receive subsidies and those that do not. This section also investigates the potential issues that arise with regard to other related definitions such as sustainable energy and low carbon energy. Section 4.3 examines the arguments underlying why renewable energy is perceived as special and therefore required, and looks at renewable energy in the wider context of the energy system. In particular, this section will examine the implications of renewable energy with regard to other critical issues facing energy policy including security of supply and climate change. The latter issue is highly pertinent given the GHG emission reduction targets at the international, European, UK and sub-national levels. In aiming to achieve such climate change targets, non-renewable energy sources, particularly the so-called low carbon energy sources become potentially important. Additionally, not all fossil fuels produce the same amount of emissions.

4.2 What is renewable energy? A question of definition

The use of renewable energy sources is not a recent development.[66] Contemporary interest originated, however, with various states providing funding for renewable

[66] The use of 'renewable energy' has occurred in parallel with the evolution of Homo *sapiens*, for example, in the use of fire for lighting and food preparation (biomass). More analogous with contemporary usage and understanding, water mills have been used for millennia as a form of power generation. Indeed, this form of renewable energy (hydro power) provided the energy to power the early industrial revolution in the UK, before being replaced by fossil fuels, primarily coal.

energy research design and development (RD&D) from the 1970s. Since 1989 the UK Government has set a number of targets for renewable energy and has provided financial support for its use ever since.[67] Numerous reasons have been put forward highlighting the importance in promoting renewables, including security of supply, fossil fuel depletion, energy dependency (on fossil fuels such as oil and gas), encouraging domestic industries to develop capabilities for both domestic and export markets and environmental reasons (Wood and Dow, 2011).

It is with regard to the latter, particularly the perceived threat of climate-damaging greenhouse gas (GHG) emissions contributing to climate change that has created the momentum for a large number of nations to develop and implement renewable energy strategies and targets. Indeed, the EU effectively made climate change its central policy focus in 2008, transferring environmental issues from the periphery to the core. The fact that the EU went much further than supporting the Kyoto Protocol by pursuing two parallel policies (the promotion of renewables through the 2009 Renewable Energy Directive (RED) which established the 2020 targets for renewable energy and the EU Emissions Trading Scheme (EU ETS) show how significant renewable energy has become at the international and national level (Helm, 2009). Critically, renewable energy is increasingly viewed as one of the main 'pillars' alongside energy efficiency in any transition to a future global sustainable energy system (Scrase and MacKerron, 2009). Therefore, the current importance attached to renewable energy can be clearly seen.

The use of the term 'renewable energy' appears to be credible, with a relatively long history of usage from the 1970s onwards[68] and a legal basis in the UK for over two decades: in order to set renewable targets and operate a delivery programme to

[67] Increasingly ambitious renewable energy targets have been consistently set from the 1990s onwards at the EU level, including a target 12 percent of gross energy consumption by 2010 (European Community [EC], 1997), 10 percent RES-E target also by 2010 (EUR-Lex, 2001). For information on renewable energy targets at the EU, UK and sub-national level, see Chapter Seven,).

[68] The distinction and thus categorisation of renewable and non-renewable energy sources most probably became widely used around 1973-1975 as one of the outcomes of work on energy security issues and sustainability (Gritsevskyi, 2010).

support the promotion and uptake of renewable energy, it is necessary to define on a legal basis what constitutes a renewable energy source in order to receive a subsidy or other special consideration. Prior to the implementation of the first EU renewable energy directive in 2001, the UK had already commenced operation of the Non-Fossil Fuel Obligation (NFFO) as the subsidy mechanism to support renewable energy in 1990 as established by the UK Electricity Act 1989. Section 32 (8) of the Act defined a renewable source as

> "*… sources of energy other than fossil fuel or nuclear fuel but includes waste of which not more than a specified proportion is waste which is, or is derived from, fossil fuel*" (National Archives, 1989: 54).[69]

Specific definitions of renewable energy sources (fuels or technologies) were contained in the actual NFFO Orders. These included wind, hydro, wave (only for SRO Order 3 in 1999) and biomass, incorporating landfill gas, sewage gas, waste and other combustion (National Archives, 1994).

Articles 2(a) and (b) of the 2001 EU Directive '*2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market*' (Eur-Lex, 2011) provided the first EU-wide renewable energy target and, importantly, a definition of renewable energy sources and expanded on the UK base to include, in addition, geothermal, tidal, solar and biogases. Article 2(e) in particular defined biomass to include the biodegradable fraction of products, waste and residues not just from vegetal (plant) materials but also from animal, industrial and municipal waste. For the purposes of the 2009 Directive '*2009/28/EC on the promotion of energy from renewable source*', the definitions in the 2001 Directive applied.[70] Replacing the NFFO in 2002, the UK Renewables Obligation (RO) maintained the same legal definition of a renewable

---

[69] Fossil fuels were defined in section 32(8) as "*coal, substances produced directly or indirectly from coal, lignite, natural gas, liquid petroleum, or petroleum products.*" (National Archives, 1989 :53)

[70] Retaining a focus on renewable electricity, additional definitional inclusions basically expanded on previously accepted forms of renewable energy such as aerothermal (energy stored in the form of heat in the ambient air and hydrothermal (energy stored in the form of heat in surface water) renewable sources. Wave and tidal were amalgamated into 'ocean energy' to incorporate the broad range of technologies at the design and development stage (Europa, 2009: see Article 2(a), (b) and (d).

energy source as also set out in the legislation that formed the legal basis of the RO, the Utilities Act 2000 (National Archives, 2000, 2002; Office of Gas and Electricity Markets [OFGEM, 2011a).[71] Curiously, the Renewables Obligation Orders (ROO) provides a definition of a hydroelectric generating station (for large scale and micro) but not for a RO qualifying generating station per se.[72] Instead, the various ROO set out the various factors that are required to be taken into account when determining what constitutes a qualifying generating station: for the most part, these concern eligibility rules for technologies or fuel sources such as biomass, fossil derived bioliquids, waste and co-firing stations (this will be looked at in more detail when the various renewable energy technologies are examined in chapter seven.

These examples from the main UK and EU legislation do not, however, provide an answer to what a renewable energy source *is*. The legal-based definitions only define renewable sources as what they are not (nuclear, fossil fuels) or list the specific technologies or energy sources that are eligible for support under the legislation/Directives. In other words, on what basis is the term renewable energy actually specified? And how credible is the apparent consensus over the actual definition?

There are numerous definitions of renewables in the literature, and for the most part all highlight the key issues with regard to a definition of renewable energy: the idea or concept of renewing or replenishing of the resource and the time horizon for the replenishment of the resource.[73] The International Energy Association (IEA),

[71] Section 62(8) maintained the same definition of renewable (and fossil fuel) energy sources (National Archives, 2000).

[72] The document '*Renewables Obligation: Guidance for Generators*' (OFGEM, 2011b: 60) states that in the absence of such a definition, the 'ordinary' meaning of a generating station should be used, such as from the English Dictionary ("as a building and site for generating electrical current") or Oxford English Dictionary ("as a power station for the generation of electricity"). Obviously such definitions exclude generation that falls under the small-scale Feed-in Tariff (FIT) and Renewable Heat Incentive (RHI) mechanisms.

[73] Interestingly, at the international level, the '*United Nations Framework Convention on Climate Change*' text (UNFCCC) does not mention renewables once, referring indirectly only to "technologies… that control, reduce or prevent anthropogenic emissions of greenhouse gases" (United Nations [UN], 1992: 10; Article 4(c) or environmentally sound technologies (Article 5, page 11), whatever that means. Article

Organisation for Economic Co-operation and Development (OECD) and Eurostat document '*Energy Statistics Manual*' (2004: 115) contains the following definition that best exemplifies this:

> "*Renewable energy is energy that is derived from natural processes that are replenished constantly… There are various forms of renewable energy, deriving directly or indirectly from the sun, or from heat generated deep within the earth. They include energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, solid biomass* [and] *biogas (wood and wood wastes, landfill gas, sewage gas, industrial wastes and municipal solid wastes) and liquid biofuel.*"

Sorensen (2000: 3) defines renewable energy in a similar manner as "*energy flows which are replenished at the same rate as they are used*". Significantly, none of the definitions of renewable energy specify that they have to be zero (or more realistically, low) carbon, yet this is a commonly held conception of what a renewable energy source is.[74]

In contrast, at the UK level, the now defunct Department of Trade and Industry's (DTI) document '*New and Renewable Energy Prospects for the 21st Century*' provided a more specific non-legal definition of renewable energy that also encompassed the GHG emitting characteristics of renewables.[75] The 1999 document (National Archives, 1999: 7) stated that

> "*Renewable sources of energy are those which are continuously and sustainably available in our environment such as wind and energy. These sources… in particular, … generally emit no greenhouse gases or are neutral over their lifecycle in greenhouse gas terms, for instance, energy crops* [taken to mean here as including biomass in general]."

2(a)(iv) of the Kyoto Protocol document mentions "new and renewable forms of energy", an obviously ambiguous term lacking any distinction between the two (UN, 1997: 2).

[74] Even a cursory examination of the literature on renewable energy highlights this assumption that renewable energy sources are, at the least, a form of very low carbon generation (see below).

[75] The document also provided a distinction between 'new' and 'renewable energy' that was lacking in definitions at the international level. The new energy sources category, however, only included fuel cells (DTI, 1999).

By 2001, however, this definition was watered down in the DTI's Renewables Obligation statutory consultation document (also confusingly called '*New Renewable Energy Prospects for the 21st Century*') to the following: "*Renewable energy, at its most basic level, can be thought of as energy that occurs naturally and repeatedly in the environment.*" (National Archives, 2001: 8).The key issues here are that the change in definition between the 1991 and 2001 documents means that technologies like landfill gas, sewage gas, energy from waste and biomass in general are provided for in the non-legally based definition and that renewable energy should be zero or carbon neutral in terms of GHG emissions.

Helm recognises the importance of these key issues, eloquently arguing that there is no consensus over what is a renewable energy source. Helm (2009: 233) states:

> "*Curiously, the very notion of a renewable is ambiguous: there is no clear definition – indeed, the concept itself is at best a relative one. It is not just a matter of semantics: the precise definition determines what is inside the protected domain [*receives subsidy*] and what is outside.*"

Helm suggests that in order to reach a definition it is necessary to determine something intrinsic in a source of renewable energy, that is, the energy source in some way 'renews' itself, and thus use does not reduce future availability. This, it is argued, includes all the major renewable energy sources such as solar, wind and water (including hydro, wave and tidal) whilst excluding biomass and biogas presumably due to the issue of sustainability. Although this agrees with the Oxford English Dictionary (2011) definition of renewables as 'a source of energy that is not depleted by use, such as water, wind or solar power', this interpretation of the issue over the definition of renewable energy ignores the possibility to utilise biomass-based renewable energy whilst restricting usage to a level that takes into account the renewing properties of the resource (incorporating an appropriate timescale for exploitation) and thus the sustainability of the resource in question. Indeed, such an approach is already adopted at least in the EU and within the UK. Rather, it comes down to the question of the rate of use of the resource: uncontrolled or over-exploitation would lead to a reduction in the ability of the resource to renew itself.[76] Such an approach would fit better with alternative definitions of renewable energy (see above).

There are, however, two main problems with this approach. First, biomass grown for energy generation (including energy crops) are not typical examples of a naturally (intrinsically) replenishing energy source. Hardly a natural process, modern industrial agriculture is a predominantly hydrocarbon based business, critically dependent on hydrocarbon-based products such as fertilisers, pesticides and mechanised farming practices. There would also be the critical question of sustainably sourcing the biomass (Committee on Climate Change [CCC], 2011). Second, a breakdown of the overall biomass category shows that there are a number of energy sources that have historically been classified as renewable energy sources yet are not naturally renewing in the way set out in the definitions. For example, landfill gas, sewage gas and many types of waste (in particular, industrial and municipal solid waste), as indirect products of human consumption, are not intrinsically or naturally renewing.[77]

There is also the issue of greenhouse gas emissions, and this helps to establish what the real distinction between renewable and low carbon energy actually is. Helm is right to highlight the issue of ambiguity, but for different reasons. This is important because the terms '*low carbon*' and '*renewable*' are implicitly taken to mean that they emit significantly less greenhouse gas emissions than fossil fuels. Renewables are seen as natural and renewing, replenished by natural sources of clean energy (i.e. non-polluting) whereas the term low carbon implies low emissions of carbon and other

[76] This does not mean that such an approach will necessarily be successful, but what is obvious is that biomass resources have always been renewed or replenished naturally. Biomass resources, however, would only be able to renew itself back to a certain amount, dependent on the level of use. Renewable resources whose exploitation eventually reaches a level beyond which replenishment will become impossible are termed 'conditionally renewable resources', in contrast to 'renewable natural resources' that, after exploitation, can return to previous levels by natural process of replenishment or growth (UN, 1997). This also has implications for hydro power.

[77] The inclusion of these particular energy sources is further complicated if the sources are constrained, and this is already the case at least in the EU (cf, the EU Waste Framework Directive 2006/12/EC (Eur-Lex, 2006) and the Landfill Directive 1999/31/EC (Eur-Lex, 1999). The question then of whether or not they should be included in the definition becomes a valid one. Continuing this line of argument, it would be more accurate to discuss fast breeder nuclear reactors (see below).

greenhouse gases. All energy production and consumption involves some carbon or other greenhouse gas production, however, and this includes without exception all energy sources, whether low carbon or renewable. Such assumptions, then, require answers to the following questions: is there an agreed understanding (at the scientific and/or political level) of what the terms low carbon and renewables actually mean with regard to GHG emissions? Significantly, do low carbon and renewable sources emit less GHG than fossil fuels? These are critical questions for a number of reasons, not just with regard to combating climate change and meeting legally-binding GHG emission targets (of which the renewables targets are a component of), but also relating to issues of credibility, particularly with regard to technology subsidy.

The literature is quite clear regarding which technologies are included in the renewable and low carbon categories, with the latter containing renewables, nuclear and carbon capture and sequestration (CCS) (CCC, 2010). With regard to '*acceptable*' GHG emissions, the UK Government (as stated previously in this chapter) has stipulated that the level of GHG emissions from renewables should be zero or neutral over the lifecycle of the technology.[78] In contrast, regarding low carbon energy sources, the 2006 document '*Carbon Footprint of Electricity Generation*' (Parliamentary Office of Science and Technology [POST], 2006: 4) provides a rare definition: "*'Low carbon' technologies have low life cycle carbon emissions (<100gCO_2eq/kWh)*". As will be shown below, and due to the lack of any supporting explanation, this appears to be a rather arbitrary limit: what would be the difference in setting the limit at 120, 150 or even 200gCO_2eq/kWh?[79]

[78] This means that any generated GHG emissions should be fully offset for any RET from the 'cradle to the grave'. In comparison to data that only takes into account emissions caused directly at the point of generation (for example, stack emissions), the life cycle assessment approach (LCA) aims to provide a more complete picture by accounting for total greenhouse gas emissions from all stages of the generation of power from electricity generation technologies. This includes construction, maintenance, capacity factor, site factor, fuel extraction, processing and transport, final use and decommissioning and disposal. Not all of these stages will apply to every technology, given the number and diversity of technologies both at the overall and sub-category level. It is expressed as grams of CO_2 equivalent (thus accounting for the varying global warming impacts of other greenhouse gases) per kilowatt hour (kWh) of generation (gCO_2eq/kWh).

[79] The updated version of this report in 2011 (POST, 2011) omits this definition, and no other definition was found by the author. Interestingly, the document omitted CCS but not nuclear power from inclusion in the section on low carbon technologies – instead, CCS was included in the fossil fuel technologies

Table 4.1 (page 107) details the greenhouse gas emissions for a number of technologies from the three main technology groups (fossil fuels, low carbon and renewables).[80] Three major points can be made from the data. Firstly, the range of GHG emissions from three technology groups potentially exhibit higher amounts than the 100gCO_2eq/kWh limit: CCS coal and gas (92-280 and 40-200gCO_2eq/kWh, respectively), solar photovoltaics (32-116+gCO_2eq/kWh) and biomass (14-580gCO_2eq/kWh). Secondly, the level of GHG emissions for biomass represents highly significant variation, with considerable potential overlap existing when compared to the lowest GHG emitting fossil fuel technology, natural gas. No other renewable or low carbon technologies exhibit potential overlap with any of the fossil fuels (although there are valid concerns regarding nuclear power, see below). Third, all other technologies classified within the renewables category exhibit GHG emissions below the 100gCO_2eq/kWh limit. Importantly, they consistently show emissions of 50gCO_2eq/kWh or less.[81]

Renewable energy supply technologies represent a distinctly heterogeneous category, incorporating many different technologies and fuels with very different characteristics (Boyle, 2004). The overall biomass category exemplifies this, with technologies and fuels involved in the production of electricity, heat and transport and including waste, energy crops, biomass and algae. Focusing on large scale electricity generation, this wide range of technologies and fuel types subsumed within the biomass category therefore are characterised by very different GHG emission profiles:

---

section. It is also unclear whether or not the limit for low carbon is based (and to what extent) on meeting climate change targets in addition to establishing a credible and useful difference between high carbon and low carbon emitting energy technologies.

[80] It should be pointed out here that a full resolution of the issues of GHG emissions from low carbon and renewable energy sources is out-with the scope of this dissertation. The point here is not to undertake an exhaustive analysis of the carbon footprint of electricity technologies *per se*, but rather to highlight the main trends and issues.

[81] Table 4.1 does highlight that even when biomass and solar photovoltaic are exempted there is still considerable variation in emissions according to different studies. There are a number of reasons for this, including site location, capacity factor, methodology (for example, examining one site or more, inclusion of more than one sub-category technology type). The important point of relevance to this chapter is that these particular RETs consistently exhibit low GHG emissions.

Table 4.1 Greenhouse gas emissions from fossil, low carbon and renewable energy technologies

Studies	GHG emissions by technology (gCO_2eq/kWh)											
	Fossil Fuels			Low Carbon			Renewable [4]					
	Coal	Oil	Nat. Gas [1]	CCS [2]		Nuclear [3]	Wind		Solar PV	Hydro	Biomass [5]	Marine[6]
				Coal	Gas		Onshore	Offshore				
Weisser (2007)	950-1250	500-1200	440-780	92-145	40-152	2.8-24	8-30	9-19	43-73	1-34	35-99	-
Hondo (2005)	975	742	607	-	-	24	29.5		53	11	-	-
POST (2006)	800-1000	650	500	-	-	5-6.8	4.64	5.25	58	10-30	25-93	25-50
POST (2011)	786-990	-	420-620	160-280	140-200	26+	5	9-13	75-116+	-	60-550	-20-50
IEMA (2009)	755-1050	650-778	385-500	-	-	-	4.64-10	5.25-9	32-58	10-30	14-93	-
CCC (2011)	-	-	-	110	50	20		<50	>50	<50	-	-
AEA (2006)	-	-	-	-	-	2.28	-	-	-	-	-	-
DECC (2008)	-	-	-	-	-	7-22	-	-	-	-	-	-
IPCC (2007)	-	-	-	-	-	<40	-	-	-	-	-	-
Lenzen (2008)	-	-	-	-	-	60-65	-	-	-	-	-	-
EA (****)	-	-	-	-	-	-	-	-	-	-	20-580	-

Note: Not all studies use same methodologies and not all figures represent full lifecycle cumulative emissions.Data ranges can indicate different technologies within the category (marine includes wave, tidal stream, range and barrier; hydro includes run-of river and reservoir; CCS includes pulversied coal, IGCC and CCGT), different fuel types (biomass) or different level of fuel richness (uranium enrichment level for nuclear). [1] Does not include shale gas (might lead to higher rates of methane leakage (CCC, 2011) or LNG which has higher GHG emissions due to fuel transportation. [2] Data range between the studies due to differences in technology (CCGT, IGCC, pulverised coal) and whether or not further potentially significant emissions from extraction, fuel delivery, type and use and methane leakage rates are included (Odeh and Cockerill, 2008). [3] Data range varies primarily due to whether or not all 14 stages of the nuclear fuel-cycle are analysed, fuel grade, primary energy carriers and uncertainty over decommissioning and storage. [4] Data varies for different renewables due to a number of reasons including assumptions of technology lifetime and capacity factor, site location and type of technology (Hondo, 2005). [5] Difficult to provide biomass GHG data due to range of technologies, fuels and indirect variables impacting on GHG emissions (land use, transport, etc). Higher range (e.g. POST, 2011) due to inclusion of more variables in study (see text for explanation). [6] Negative values arise from a high level of assumed carbon sequestration via upstream silt deposition due to the barrage structure used in tidal barrage technologies (Parsons Brinckerhoff, 2010).

Abbreviations: POST (Parliamentary Office of Science and Technology); IEMA (Institute of Environmental Management & Assessment); CCC (Committee on Climate Change); AEA (AEA Technology plc); DECC (Department of Energy & Climate Change); IPCC (Intergovernmental Panel on Climate Change); EA (Environment Agency, UK).

"F*or example, using short rotation coppice chips to generate electricity can produce 35 to 85 per cent less emissions than a combined cycle gas turbine power station per unit of energy delivered, whereas using straw can, in some cases, produce over 35 per cent more… Using formerly fallow land to grow bioenergy crops can reduce emission savings from a fuel by up to 10 per cent. Planting on permanent grassland is worse, with emissions savings significantly reduced and in some cases reversed.*" (Environment Agency, 2011: iv).

In other words, some but not all biomass RETs will produce GHG emissions that will overlap with fossil fuel emission characteristics (natural gas) or breach the 100gCO_2eq/kWh limit. This will also be dependent on a wide range of issues including land-use, transport, fertiliser use (and type of agricultural practice) not to mention overall practice. However, if the greenhouse gas emissions for certain biomass RETs/fuels fall into the upper or even mid-range, designation as a renewable energy source viable for protection (subsidy) is clearly open to challenge. This is important because biomass is one of the few RETs that could play a critical role as a non-intermittent, base-load renewable energy source (these issues will be examined further in chapter five).[82] Further, the high GHG emissions profile of certain biomass technologies and fuel sources can lead to significant opposition particularly at the planning stage (see chapter eight, section 8.2). However, CCS is not just limited to fossil fuel technologies, but can also be utilised for biomass.

Adoption of the life cycle assessment approach (LCA) also has interesting implications for CCS and nuclear power, the two low carbon energy sources. In the case of CCS, data at the lower end of the range, approximately around 100gCO_2eq/kWh or lower, represents stack emissions:

"*Carbon capture and storage (CCS) has higher lifecycle emissions [*in general than renewable technologies*]. Residual emissions from fuel combustion, assuming a 90% capture rate, are around 50 and 110 g/kWh for gas and coal CCS respectively, with further potentially significant emissions from extraction and delivery of the fuel, related to energy use and related to its source.*" (CCC, 2011: 47).

[82] However, it is important to remember that despite uncertainty over the GHG emission characteristics of nuclear and certain biomass RETs, both are accepted sources of low carbon and renewable energy, respectively, in the UK and within the EU and abroad [National Archives, 1999].

The higher ranges for both technologies, shown by the use of lifecycle analysis, therefore represent more accurate accounts of GHG emissions, reducing the potential benefits of both coal and gas CCS in terms of GHG emission mitigation although both would still be lower than for unabated natural gas.[83] An important point here, however, is that if fossil fuel use in the electricity sector continues to dominate or even account for a major proportion of electricity generation, as it historically and currently does, this would have the additional effect that CCS could play an important role in electricity sector decarbonisation by permitting traditional fossil fuels to continue to be utilised whilst acting as a low or, more realistically, lower carbon back up, particularly for the intermittent renewable technologies like wind, solar and marine power (this will also have implications for the GHG emissions profile of nuclear power, see below). With regard to solar photovoltaic, the highest figure (116gCO_2eq/kWh), representing a dominant technology (mono-crystalline silicon technology), is significantly less than for CCS when lifecycle emissions are taken into account and not all solar photovoltaic technologies exhibit such high GHG emission profiles.

Table 4.1 also shows that, in general, nuclear power has a GHG emissions profile similar to that of the lowest emitting renewable energy technologies, for example wind (4-30gCO_2eq/kWh), hydro (1-34gCO_2eq/kWh), marine (-25-50gCO_2eq/kWh) and certain biomass and solar photovoltaic technologies. This is in agreement with the acceptance of nuclear power as a low carbon energy source by the UK Government (BERR, 2008) and a number of prestigious organisations such as the World Energy Council [WEC] (2004), the Intergovernmental Panel on Climate Change [IPCC] (2007) and the UK Committee on Climate Change (2011). The status of nuclear power as a low carbon source of energy is important given that nuclear power, in comparison to CCS, is a mature technology with the potential to be currently deployed at scale in addition to acting as a significant source of low carbon base-load electricity generation.[84]

[83] Given the current lack of commercial-scale experience, there still remains uncertainty over the actual life cycle GHG emissions associated with carbon capture and sequestration technology [POST, 2011].

[84] There are, of course difficulties regarding the proposed new nuclear build in the UK but at the very least the potential is there unlike CCS which is still a relatively unproven (commercially) technology.

There are, however, apparently valid concerns over such a low greenhouse gas emissions profile for nuclear power. There are three main reasons for this: the quality (grade) of uranium reserves, uncertainty over decommissioning and long-term storage and the difficulties inherent in assessing the life cycle GHG emissions from nuclear power. In contrast to higher-grade uranium ores (with at least 0.1 percent uranium oxide, or yellowcake U_3O_8), lower-grade uranium ores (>0.01 percent U_3O_8) are at least ten times less concentrated than high-grade ores. This means that

> "*... it takes 10tons of ore to produce 1 kg of yellowcake. Put another way, if uranium ore grade declines by a factor of ten, then energy inputs to mining and milling must increase by a factor of ten.*" (Sovacool, 2008: 2945).

Higher-grade ores also create significantly less radioactive waste to be transported and managed (Schrader-Frechette, 2009, 2011). In other words, use of lower-grade uranium ores can greatly skew estimates and increase the GHG emissions profile of nuclear power (Barnaby and Kemp, 2007; Lenzen, 2008; POST, 2011).[85] The real issues, then, are as follows: what is the size and grade (quality) of global uranium reserves? How accessible are these reserves (in geographical, political, technical, economical terms)? Obviously, if higher-grade ore deposits are depleted or inaccessible for one or more of the above reasons, this will leave lower-grade uranium ore for nuclear power.[86]

With regard to decommissioning and storage, there is little experience and therefore any data is mainly derived from estimates (Sovacool, 2008; Schrader-Frechette, 2011).

---

[85] Focusing specifically on the UK, the government published '*A White Paper on Nuclear Power*' in 2008 (BERR, 2008) which stated that GHG emissions ranged from 7-22gCO_2eq/kWh. This document quoted figures from companies heavily involved in operating nuclear power stations such as Vattenfall (3.10gCO_2eq/kWh) and British Energy (5.05gCO_2eq/kWh). However, others have argued that these studies failed to take account of the impact of lower grade ore usage (in addition to failing to analyse all 14 stages of the nuclear life cycle (Schrader-Frechette, 2011).

[86] However, if low carbon or renewable energy sources are utilised (at least on a greater scale than currently evidenced) throughout the nuclear life cycle, this would reduce the GHG emissions significantly. For example, although the study by Lenzen et al. (2008) included in Table 431 shows a higher GHG emissions profile (60-65gCO_2eq/kWh), a subsequent analysis showed that this high result was due primarily to a coal-dominated primary energy carrier mix (the study was carried out in Australia where around 92% of electricity generation is from coal). With an EU-mix, the overall GHG emissions profile was reduced to 33% (Beerten et al. 2009).

Critically, there are a number of difficulties in assessing the life cycle GHG emissions from nuclear power (although the same could be said for various other technologies). In addition to those already mentioned (uranium-ore quality, primary energy carrier, limited knowledge and experience in certain stages of the life cycle), there are also problems arising from the scope and methodologies utilised in the various studies, type of mining, enrichment process, reactor technology, site selection and operational lifetime. Additionally, nuclear power is also a highly emotive subject. As Sovacool (2008: 2951) states:

> "*Rather than detail the complexity and variation inherent in the greenhouse gas emissions associated with the nuclear lifecycle, most studies obscure it; especially those motivated on both sides of the nuclear debate attempting to make nuclear energy look cleaner or dirtier than it really is.*"

In other words,

> "*... nuclear power has a long and complex lifecycle, with CO_2 emissions spread unevenly throughout... It is important to understand that the scale of the uncertainties is very large indeed, and that any claims that hard-and-fast figures for emissions over a nuclear plant's lifetime can be calculated accurately should be treated with scepticism. Moreover, there are still too many unknowns, not least because no nuclear facility has ever been decommissioned.*" (Porritt, 2012: 6).

There is a need for a more accurate, accountable, comprehensive and transparent analysis of the lifecycle GHG emissions associated with nuclear power. This will improve the credibility of nuclear power as a low carbon source of energy, unless the emissions attributed to the use of lower-grade U_3O_8 or to the decommissioning and long-term storage substantially increase the GHG emissions profile of nuclear above what could be an acceptable level as some argue.

The lack of a consensus of what constitutes a low carbon or renewable energy source in terms of GHG emissions, in particular the inclusion of certain biomass technologies within the definition of what is a source of renewable energy, thus appears to give credence to Helm and others claims that the definition of renewable energy is wrong, or at least ambiguous, on the one hand creating a very politically convenient flexibility but also creating uncertainty for investors (Helm, 2009) and that the distinction between renewables and low carbon is thus artificial. But this ignores the fundamental distinction. Renewable energy sources are intrinsically renewing, dependent on the management of the resource in question, whereas low carbon sources such as nuclear power and carbon capture and storage (CCS) are not. Unlike biomass, which can be re-grown, uranium and coal cannot.

However, this in turn begs the question: Why is the renewing aspect of the definition of what constitutes a renewable energy source, particularly when biomass is included, so important? There appear to be two answers to this. Firstly, an energy source that intrinsically renews itself is infinite and thus more sustainable (including if the resource is properly managed in the case of biomass). It could also contribute significantly to issues of security of supply. Second, such a definition could be revised, varying what is inside (and outside) the protected domain. In other words, it has potentially significant political benefits in being 'flexible'. Both answers have merit, with the former being more commendable. If the overarching aim is to meet the legally-binding climate change targets, however, then is the distinction between the energy source being renewing versus non-renewing more important than combating climate dangerous GHG emissions, at least in the short term? It is not unreasonable to assume that increased climate change would be a worse situation globally than the exploitation of nuclear power, until uranium ran out and one or more technologies became viable at the necessary scale and timeframe. At the very least, arguments for defining fast-breeder nuclear reactors out of the renewables definition begins to look weak (or political). Taking the argument about certain biomass energy sources, for example, such as landfill gas, sewage gas, municipal solid waste and so on, Cohen (1983) has argued that fast breeder reactors, fuelled by naturally-replenishing uranium extracted from seawater could supply energy for as long as energy sources traditionally defined as renewable (in other words, as long as the sun's remaining expected lifespan of around five billion years). This would provide an example of a technology that fitted the definition of a renewable energy source.[87]

[87] Although currently fast breeder nuclear power does not contribute to global energy at any scale, this is not the point: at the least this example shows how open to interpretation the definition of renewable energy currently is, and thus could either be included in the definition or the term renewable energy

The debate over the current definition of what constitutes a renewable energy source is not confined to whether or not to include nuclear power, or specifically fast breeder nuclear technology. During EU negotiations for what would become the RED (EU Directive 2009/28/EC), the then UK Government argued the case that carbon capture and sequestration, due to its potential role as a vital new low carbon technology of global significance on which the EU could lead the way, should be "*taken into account in assessing Member States compliance with national renewable targets. Of course CCS is not a renewable, but this could be treated as a special case…*" (Council of the European Union, 2008: 3). This is highly significant, revealing how politically fluid the approach to the definition for renewable energy actually is, and how the target should be met. And this is not the first example of such an approach. In 2005, the then Parliamentary Undersecretary for the DTI, Lord Sainsbury of Turville, stated that nuclear power should be reclassified as a renewable energy source (Innovation, Universities, Science and Skills Committee [IUSS Committee, 2008a).[88] Although nuclear power and CCS have not been defined as renewable in any sense, and are unlikely to be, the on-going electricity market reform (EMR) process appears to be attempting to side-step the issue by proposing long-term feed-in tariff contracts for difference (FIT CfD) for renewables, nuclear power and carbon capture and sequestration, with numerous and complex interactions likely to occur as a result. There is also the issue of whether or not the EU will adopt a post-2030 renewables-specific target, move towards a broader 'low-carbon' target.

changed (expanded) to renewable low carbon energy sources. However, this would not solve the problems associated with the inclusion of biomass within the definition. The other major technology category placed within the designation of low carbon energy sources, carbon capture and sequestration (CCS) on the other hand would not as coal is not renewing, at least on any satisfactory timescale of replenishment. These are not new arguments. Interestingly, the UN document '*UN Glossary of Environment Statistics F-67E*' (UN, 1997: 51) containing the term 'new and renewable energy sources' included peat, oil shale and tar sands. A previous version of the document also included fast breeder nuclear reactors (Gritsevskyi, 2010).

[88] The actual quotation by Lord Sainsbury is as follows "*… nuclear is a renewable source of energy, it clearly is so. I am very happy to agree that nuclear is a renewable source of energy.*" (IUSS Committee, 2008a: Ev190: 196). This was strongly rebutted by the committee in the same report 'Renewable Energy Generation Technologies': "*We agree that nuclear energy is not a form of renewable energy, whatever its advantages in carbon-saving, as it relies on uranium as a fuel source.*" (IUSS Committee, 2008b: 24). Former US President George W. Bush (senior) also referred to nuclear power as '*renewable*' (IUSS Committee, 2008b).

4.3 Is renewable energy special? Renewable energy in the context of the energy system

By early 2010, more than 100 countries had some form of promotional support (subsidy) mechanism for renewable energy (mostly for renewable electricity generation, RES-E) commonly in association with some form of policy target (Renewable Energy Policy Network for the 21st Century [REN21], 2010).[89] In addition, the share of renewables in global primary energy demand stands at almost 20 percent, with electricity generated from renewable energy sources at 19 percent (International Energy Association [IEA], 2010). It is clear, therefore, that renewable energy is playing an increasingly important role in the energy system, both at the national and global level. This can also be seen in the UK, particularly with regard to renewable electricity generation, which has increased from under 2 percent in 2001 to around 7 percent in 2010 (Wood and Dow, 2010). This leads to the important issues of why it is that renewable energy, by being viewed as special or distinctive, is receiving so much policy and legislative attention.

There are numerous reasons documented in the literature for why renewable energy could be regarded as '*special*' in the sense that it confers alternative or additional benefits or helps to achieve goals or targets that would not be realised otherwise (either partially or at all). The previous section highlighted the case that by definition, renewable energy sources provide infinite sources of energy that is sustainable and that they should produce realistically very low levels of greenhouse gas emissions (in addition to other environmental pollutants). A number of important caveats are recognised, however, that reveal tensions in the definition and could weaken the argument that renewables should be viewed as special, especially in relation to low carbon technologies such as nuclear power: not all renewable energy sources are naturally (intrinsically) renewing, particularly if the exploitation of the resource is not managed properly (biomass). Other sources are not naturally renewing at all (some types of waste, including landfill gas and sewage gas), although there is logic in such

[89] This compares with the figure of fifty-five countries with similar initiatives in early 2005. In 2011 there were 196 countries recognised. The number of countries with renewable energy policies in place is approximately equal between the so-called developed and developing world as of 2010 (REN21, 2010).

potential energy streams being utilised until the problems of resolving these waste issues are resolved. Importantly, there is evidence which shows that some renewable energy sources emit higher levels of greenhouse gases than non-renewable sources (biomass). An examination of the literature (cf. Boyle *et al*, 2003; Boyle, 2004; Elliott, 2003, 2010; Komor, 2004), particularly UK Government documents from the 1990s onwards provide a fairly comprehensive list of reasons as to why renewable energy should be supported. The 2003, 2007 and 2011 '*Energy White Papers*' and various energy policy documents include the following reasons: security of supply, fossil fuel depletion and energy dependency concerns (on fossil fuels such as oil and gas), energy diversity, encouraging domestic industries to develop capabilities for both domestic and export markets and environmental reasons (including putting the UK on a path to cut GHG emissions according to legally-binding targets and reducing other environmental pollutants) (cf. DECC, 2011a,b,c; DTI, 2006; National Archives, 1999, 2001).

Leaving aside the issue of definition, can these reasons be used to argue for non-renewable energy sources? Fossil fuels are not environmentally benign, accounting for significant emissions of not just GHG but also other environmental pollutants, increase problems of energy dependency as UK indigenous reserves decline, particularly in the North Sea or are constrained by environmental legislation. In addition, most fossil fuel technologies are mature and therefore offer no real options to encourage domestic industries to expand capabilities for domestic and export markets.[90] The increase in gas-fired power stations has played an important role in increasing electricity generation diversity in the UK since the 1990s and will continue to do so with the planned increases in gas-fired generation over the next decade or so and has significant

[90] Fossil fuels (and nuclear power) do, however, contribute to employment and economic performance. In the report '*Powering the UK: The role of the power and gas sector in the wider economy*' (Ernst and Young, 2011: 2), the energy sector is argued as one that "Punches above its weight… in terms of wider economic benefits." Despite difficulties in separating the data depending on particular sectors, a number of broad trends can be observed: in 2010, the energy industries contribution to GDP (Gross Domestic Product) has declined since the 1980s (from 10.4% in 1983 to 3.4% in 2010). All energy sectors have shown significant decline. In 2010 the contribution to GDP by the oil and gas upstream industry was 1.8% (from nearly 7% in 1984), 1.3% for the electricity and gas sector (a decline of 50% from 1982). With regard to employment, all sectors showed a significant decline until 2008, primarily as a result of growth in the electricity sector (and gas) (173,000, +13.8% increase from 2009) (DECC, 2011d). However, the potential application of CCS could significantly alter the market options for coal and gas with regard to the economy. This would be dependent in part on the UK's role in developing CCS.

benefits with regard to security of supply issues, although the high level of UK energy dependency on fossil fuels, particularly gas for electricity generation, in conjunction with reduced indigenous output could aggravate this issue (Wicks, 2009).[91] Arguments have been proposed, however, that gas-fired power stations could be classified as a low or lower carbon energy source. The rationale for this is that gas produces approximately half the amount of GHG emissions of coal (IEA and the OECD, 1998). Although true in comparison to coal, on average current gas powered electricity generation has a carbon footprint of around 450-500gCO_2eq/kWh (POST, 2006, 2011). As Table 4.1 shows, this is a far higher carbon footprint than the 50gCO_2eq/kWh or less exhibited by the majority of RETs and nuclear power (although potential increases in GHG emissions from the utilisation of lower-grade uranium ore could affect the emissions profile of nuclear power), and is also higher than the current lifecycle emissions for CCS coal and gas. Critically, if the carbon footprint of certain biomass RETs do overlap with non-abated natural gas, then not only would this weaken the argument for such biomass receiving subsidy support but the potential climate change benefits of these technologies is also undermined. This does not, however, equate to an argument that gas would then become some form of low carbon energy source by default.

In contrast, nuclear power is a low carbon energy source that has the ability to deploy at a scale large enough to play a significant role in UK electricity generation, not least in low carbon generation.[92] Eight sites included in the updated (July 2011) '*National Policy Statements for Energy*' document (DECC, 2011f) could result in around 10-16 GW of new installed nuclear capacity.[93] Currently, around 10 GW of existing nuclear plant is to be

[91] Security of supply is taken here as meaning not just a supply interruption of any fuel but also non-physical impacts where supply disruption in global energy markets could also lead to higher energy prices. In electricity generation, around 75% is currently accounted for by fossil fuels with 16% from nuclear power (DECC, 2011e).

[92] In 2009 the UK set a non-legally binding target of 40% low carbon electricity by 2020 (incorporating the legally-binding UK RES-E target of 30%) (DECC, 2009). Nuclear power is expected (by the UK Government) to play a major role out with the contribution from renewable energy sources. The contribution provided from carbon capture and sequestration is currently less clear.

[93] This is based on only a single reactor built at each site. More than once reactor per site is feasible, and capacity would depend on the type of reactor technology chosen (DECC, 2011f).

decommissioned over the same time period, equivalent to the total current installed capacity in 2010 comprising 18 units at 10 sites (Department of Business, Enterprise and Regulatory Reform [BERR], 2008; DECC, 2011g; World Nuclear Association, 2011). Nuclear power could contribute in a credible manner to climate change goals and the 2020 low carbon target, but the issue of waste disposal and decommissioning is a critical one, potentially countering the environmental (or rather, the climate change) benefits. Importantly, if there was no new nuclear build, this would be a loss to diversity overall. As with any energy source, there are potential benefits to security of supply.

However, there are four main issues of concern over nuclear power's role with regard to security of supply. Firstly, unless the proposed new build programme actually goes ahead, without extending the lifespan of certain existing nuclear power stations by 2025 the UK will have no nuclear generation plant. Second, outages (planned and unplanned) occur regularly with significant corresponding losses in output[94]. Third, existing UK uranium and plutonium stocks are estimated to last for 60 years for three 1000 MW reactors (BERR, 2008). With regard to the last point, obviously 16,000 MW of nuclear power would not last so long. There is also the question of supply competition, with many countries planning to construct and operate new nuclear stations over the same period as the UK (thus requiring stocks of fuel in addition to construction materials and expertise). This last issue, it could be argued, will also impact on the proposed major expansion of renewable energy, in particular the dominant role of onshore and offshore wind to the target (see chapter six).

This analysis shows that promoting renewable energy on the reasons discussed above is not as clear as generally assumed. Although a lot of the issues examined so far in this section indicate that renewable energy could be beneficial regarding these issues, this will depend on how renewable energy policy is implemented, especially over the next

[94] For example, nuclear power output dropped by 10 percent between 2009 and 2010 due to maintenance outages alone corresponding to a drop of 7 TWh (from 69 TWh to 62 TWh) (DECC, 2011e). In 2008, nuclear power output fell to its lowest level since 1981 due to outages for repair and maintenance (DECC, 2010). Unplanned outages have also been disruptive to output: in June 2011 both units at Torness power station were closed after jellyfish were found in the seawater filters (Guardian, 2011).

few years. This is a particularly salient point. It is important to recognise that as renewable deployment rates increase, the current energy system will have to be run differently primarily due to the issues of intermittency and back-up. This will impact on the electricity network infrastructure (amongst other reasons) as the locational 'choice' of an intermittent generator cannot be controlled: for example, wind generators are strongly influenced to locate to sites of highest resource potential (this is particularly the case in the UK, due in large part to the Renewables Obligation subsidy mechanism design, see below). There are, of course, more predictable intermittent generators (such as marine renewables) which will have a different impact on the energy system as well as non-intermittent renewable energy technologies such as hydropower and biomass (both of which have their own particular problems, see chapter five).

But do these reasons actually mean that renewable energy is special? Helm (2009) argues against the need for what he calls a 'special reserved quota' for renewables. The main thrust of his arguments concerns the 'infant industry' argument. In addition to concerns over definition, Helm also argues that that the 'infant industry' argument (because renewables are new technologies subject to research and development (R&D) and costs will fall as deployment increases) is nonsense because there is little scope for R&D resulting in deployed assets by the 2020 EU target. This is misleading because the 2020 target should be viewed as a stepping stone and not an end in itself. Also, R&D will play a particularly critical role in bringing certain RETs to full deployment potential around (or more likely) after 2020, such as marine technologies: but if such support in not forthcoming in the period up to 2020, there will be no results after the current target. The problem then is the target, or rather, the failure to extend the target, not supporting renewable energy per se.[95]

The previous discussion regarding whether or not renewable energy is special in the sense of deserving distinctive treatment (Helm's '*special reserved quota*'), however,

[95] Helm actually argued this point previously, as one of three options to improve the chances of the EU target being met: broaden the technology domain (by including nuclear power, CCS and coal-bed methane), widening the geography (to include generation from outside the EU) and increasing the time period of the target deadline (cf. Helm, 2008a: 2).

misses the principal point of the current state of the UK energy system. As discussed in greater detail in chapter three, the UK electricity system was privatised and liberalised. The electricity restructuring process commenced with the sale of state assets (privatisation) in 1990-91 with the incorporation of liberalisation and competition occurring throughout the 1990s and beyond to create a market for energy. This had and continues to have obvious implications for energy, including renewables. Instead of controlling the energy sector, the government has had to establish regulators and regulations to enforce a system of competition with the minimum of distortion, with energy produced and consumed in an economically efficient way. In other words, the UK has adopted a least-cost approach based on competitive and market-based policies. As Mitchell (2008: 7) puts it

> "*The economic goal has de facto dominance… [*there is*] no choice other than by competitive means via the market… innovation should occur through competition, based on a choice by price within markets.*"

Such a system is designed to avoid '*picking winners*'. Choosing a particular technology or technologies would be considered as distorting (by intervening in) the market and therefore undermining the incentives of competition. This is critical in understanding the manner in which renewable energy has been supported in the UK from the 1990s onwards.

The policy instruments to support renewable energy sources (both the Non-Fossil Fuel Obligation and the currently still operational Renewables Obligation) were designed and operated during the establishment of the privatisation and liberalisation of the energy market. This represented a fundamental shift in energy systems – from direct government ownership to a competitive, open market. As a result, governments lost some control and influence over the resultant competitive energy system to the market (Komor, 2004).[96] For renewables, this meant the creation of a new environment in which each RET must compete not only with traditional fuels (coal, oil, gas) and nuclear

---

[96] See Helm (2008b) for a more detailed explanation of the effects of liberalisation and privatisation on renewables and energy policy

power but also, with other renewables (as will be seen later, this was particularly the case for renewables under the UK's RO mechanism). Renewable energy policy and the regulatory environment and mechanisms, however, have been designed as far as possible to conform to the principles and rules of the competitive market.

Without the segmentation of the market offered by the promotional subsidy mechanism, it is clear that renewable electricity deployment would not have increased almost four-fold over the last few decades[97]. Renewable energy technologies as a whole are typically highly capital-intensive, requiring the capital upfront, and are more costly in comparison to conventional generation per kW of capacity installed, in particular coal and gas-fired generation. Despite being a generalisation, this holds true for renewable electricity generation as a whole, although it is important to stress that the renewables category is a heterogeneous one, including many different technologies and fuels with very different characteristics. Such characteristics include technological maturity, technology type, fuel source, in addition to non-technological reasons such as subsidy level (due to technology banding), planning legislative and electricity network issues, supply chain and raw materials.[98] In a market-based energy system where cost-reduction and economic efficiency are emphasised[99], the result is that only the most technological mature technologies (those at or closer to market deployment) will evidence strong uptake by the market. This can be seen by the overwhelming dominance of onshore wind and certain biomass technologies in the UK, technologies that are already at the commercial deployment stage and not requiring significant R&D (although this is not the case currently for new biomass RETs and offshore wind to the extent of onshore wind power). In addition, marine RETs and solar photovoltaic are prime examples of RETs far from commercial deployment.

---

[97] Without any form of subsidy support mechanism for renewables, this would result primarily in the increased deployment of gas (or coal, if not for environmental constraints such as climate change legislation and the LCPD) as both exhibit low capital and operational and maintenance (O&M) costs.

[98] See chapter five for a more detailed examination of the technological issues regarding renewable energy sources.

[99] Since the introduction of privatisation and liberalisation in the energy market, the goals of UK energy policy have continuously contained the aim "*to promote competitive markets in the UK and beyond*" (DECC, 2011a: 11).

Unlike modern electricity generation from conventional and nuclear sources which benefitted from either being developed (nuclear) and deployed (nuclear, conventional thermal), contemporary renewable energy progress commenced at the same time as the market was established. After decades of a state-owned and state-managed electricity (and energy) system, the comparably short duration of the privatised and liberalised energy market can be viewed as an experiment still in process. Therefore, the segmentation of the market to protect, or more accurately promote renewables first under the NFFO and now under the RO, whether or not the reasons examined in this chapter is accepted, can not really be construed as special in any significant meaning of the word.

Returning to the issue of subsidies, in 2010 global fossil fuel subsidies amounted to $406 billion, an increase of $110 billion more than in 2009 (IEA, 2011). Both mature technologies, approximately 50 percent supported the oil industry whilst almost 25 percent went to natural gas (Business Green, 2011). In comparison, renewables received $66 billion (IEA, 2011). Such statistics are commonly used to show that fossil fuels are treated more favourably than renewables, or at the least, that subsidies are a common option globally. However, it is important not to confuse commodity and wire subsidies: a coal-fired power station cannot receive a ROC certificate (commodity subsidy) whereas most generators can use the transmission network infrastructure (wire subsidy). Renewable deployment (and output) is also currently significantly lower than that seen for fossil fuels.

References

Beerten, J., Laes, E., Meskens, G. and D'haeseleer, 2009. Greenhouse gas emissions in the nuclear life cycle: A balanced appraisal. Energy Policy 37(12): 5056-5068.

Boyle, G., Everett, B. and Ramage, J. 2003. Energy Systems and Sustainability: Power for a Sustainable Future (Eds). Oxford University press: Oxford

Boyle, G. 2004. Renewable Energy: Power for a Sustainable Future – Second Edition (ed). Oxford University Press: Oxford

Business Green, 2011. IEA demands end to $409bn a year fossil fuel subsidies – 4 Oct 2011 [online] Available from http://www.businessgreen.com/bg/news/2114302/iea-demands-usd409bn-fossil-fuel-subsidies

Cohen, B.L., 1983. Breeder reactors: A renewable energy source [online] Available from http://sustainablenuclear.org/PADs/pad11983cohen.pdf

Committee on Climate Change [CCC], 2011. Bioenergy Review – December 2011 [online] Available from http://www.theccc.org.uk/reports/bioenergy-review

Council of the European Union, 2008. Climate-Energy Legislative Package – Policy debate: Contribution from the United Kingdom – 27 February 2008 [online] Available from http://register.consilium.europa.eu/pdf/en/08/st07/st07010.en08.pdf

Department of Business, Enterprise and Regulatory Reform [BERR}, 2008. Meeting the Energy Challenge: A White Paper on Nuclear Power – January 2008 [online] Available from http://www.berr.gov.uk/files/file43006.pdf

Department of Energy and Climate Change [DECC], 2009. UK Low Carbon Transition Plan: National strategy for climate and energy [online] Available from http://www.decc.gov.uk/publications/basket.aspx?FilePath=White+Papers%2fUK+Low+Carbon+Transition+Plan+WP09%2f1_20090724153238_e_%40%40_lowcarbontransitionplan.pdf&filetype=4#basket

Department of Energy and Climate Change [DECC], 2010. Digest of United Kingdom Energy Statistics (DUKES) 2010 [online] Available from http://www.decc.gov.uk/assets/decc/Statistics/publications/dukes/348-dukes-2010-printed.pdf

Department of Energy and Climate Change [DECC], 2011a. Energy White Paper 2003: Our Energy Future – Creating a Low carbon Economy [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/white_paper_03/white_paper_03.aspx

Department of Energy and Climate Change [DECC], 2011b. Energy White Paper 2007: Meeting the Energy Challenge – A White paper on Energy [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/white_paper_07/white_paper_07.aspx

Department of Energy and Climate Change [DECC], 2011c. Energy White Paper 2011c. Planning our electric future: a White Paper for secure, affordable and low carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change [DECC], 2011d. UK energy sector indicators 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/statistics/publications/indicators/indicators.aspx

Department of Energy and Climate Change (DECC), 2011e. Digest of United Kingdom Energy Statistics (DUKES) 2010 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/2312-dukes-2011--full-document-excluding-cover-pages.pdf

Department of Energy and Climate Change (DECC), 2011f. National policy Statements for Energy Infrastructure – Overarching National Policy Statement for Energy (EN-1) – Updated July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/nps_en_infra/nps_en_infra.aspx

Department of Energy and Climate Change [DECC], 2011g. Nuclear [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/nuclear/nuclear.aspx

Department of Trade and Industry, 2006. Energy review: A Report – July 2006. HMSO

Ernst and Young, 2011. Powering the UK: The role of the power and gas sector in the wider economy [online] Available from http://www.ey.com/Publication/vwLUAssets/Powering_the_UK/$FILE/Powering_the_UK.pdf

European Commission [EC], 1997. Communication from the Commission – Energy for the future: Renewable sources of energy – White Paper for a Community |Strategy and Action Plan (COM(97)599 final (26/11/1997) [online] Available from http://ec.europa.eu/energy/library/599fi_en.pdf

Eur-Lex, 1999. Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:182:0001:0019:EN:PDF

Eur-Lex, 2001. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0077:EN:NOT

Eur-Lex, 2006. Directive 2006/12/EC of 5 April 2006 on waste [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0009:0021:en:PDF

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Gritsevskyi , 2010. Renewable vs. non-renewable energy sources, forms and technologies [online] Available from http://unstats.un.org/unsd/envaccounting/londongroup/meeting13/LG13_13a.pdf

Guardian, 2011. Jellyfish shut down nuclear reactors – Thursday 30 June 2011 [online] Available from http://www.guardian.co.uk/environment/2011/jun/30/jellyfish-shut-nuclear-reactors-torness

Helm, 2008a. Renewables – time for a rethink? [online] Available from http://www.dieterhelm.co.uk/node/488

Helm, 2008b. Energy, the State, and the Market: British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford

Helm, 2009. EU Climate Change policy – A Critique, in: Helm, D. and Hepburn, C. (Eds), The Economics and Politics of Climate Change. Oxford University press: Oxford

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008a. Renewable electricity generation technologies – Volume II – Fifth Report of Session 2007-08 – 11 June 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/cmdius.htm

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008b. Renewable electricity generation technologies – Volume I – Fifth Report of Session 2007-08 – 11 June 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/cmdius.htm

International Energy Association [IEA], 2010. World Energy Outlook 2010 [online] Available from http://www.iea.org/Textbase/npsum/weo2010sum.pdf

International Energy Association [IEA], 2011. World Energy Outlook 2011 [online] Available from http://www.iea.org/weo/docs/weo2011/homepage/WEO2011_Press_Launch_London.pdf

International Energy Association [IEA] and the Organisation for Economic Co-operation and Development [OECD], 1998. Benign Energy? The Environmental Implications of Renewables [online] Available from http://www.iea.org/textbase/nptoc/archive/Benign1998_TOC.pdf

International Energy Association [IEA], Organisation for Economic Co-operation and Development [OECD] and Eurostat, 2004. Energy Statistics manual [online] Available from http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/NRG-2004/EN/NRG-2004-EN.PDF

Komor, P. 2004. Renewable Energy Policy. The Diebold Institute for Public policy Studies

Mitchell, C. 2008. The Political Economy of Sustainable Energy. Palgrave Macmillan

National Archives, 1989. Electricity Act 1989 [online] Available from http://www.legislation.gov.uk/ukpga/1989/29/contents

National Archives, 1994. The Electricity (Non-Fossil Fuel Sources) (England and Wales) Order 1994 [online] Available from http://www.legislation.gov.uk/uksi/1994/3259/article/1/made

National Archives, 1999. New and renewable Energy: Prospects for the 21st Century (formerly published by the Department of Trade and Industry, DTI) [online] Available from
http://webarchive.nationalarchives.gov.uk/+/http://www.dti.gov.uk/renew/condoc/

National Archives, 2000. Utilities Act 2000 [online] Available from http://www.legislation.gov.uk/ukpga/2000/27/pdfs/ukpga_20000027_en.pdf

National Archives, 2001. New and Renewable Energy: Prospects for the 21st Century – The Renewables obligation Statutory Consultation (formerly published by the Department of Trade and Industry, DTI) [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file21090.pdf

National Archives, 2002. Statutory Instruments 2002 No.914 Electricity, England and Wales – The Renewables Obligation Order 2002 [online] Available from http://www.legislation.gov.uk/uksi/2002/914/pdfs/uksi_20020914_en.pdf

Office of Gas and Electricity Markets [OFGEM], 2011a. Renewables Obligation – What is the Renewables Obligation (RO)? [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

Office of Gas and Electricity Markets [OFGEM], 2011b. Renewables Obligation: Guidance for generators – May 2011 [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Documents1/RO%20Generator%20Guidance%20May%202011%20final.pdf

Oxford English Dictionary, 2011. Definition of renewable [online] Available from http://oxforddictionaries.com/definition/renewable

Parliamentary Office of Science and Technology [POST], 2006. Carbon footprint of electricity generation – October 2006 Number 268 [online] Available from http://www.parliament.uk/documents/post/postpn268.pdf

Renewable Energy Policy Network for the 21st Century [REN21], 2011. Renewables global Status Report [online] Available from http://www.ren21.net/
Scrase, I. and MacKerron, G. 2009. Energy for the Future – A New Agenda (Eds). Palgrave Macmillan

Sorensen, B. 2000. Renewable Energy – Second Edition. Academic Press

United Nations, 1992. United Nations Framework Convention on Climate Change [online] Available from http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

United Nations, 1997. Glossary of Environmental Statistics – Studies in Methods Manual Series F No 67E [online] Available from http://unstats.un.org/unsd/publication/SeriesF/SeriesF_67E.pdf

United Nations, 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change [online] Available from http://unfccc.int/resource/docs/convkp/kpeng.pdf

Watson, J., Scrase, I., and Stapleton, L., 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Wood, G. and Dow, S. 2011. What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy. Energy Policy 39(2011): 2228-2244

World Nuclear Association, 2011. Nuclear Power in the United Kingdom [online] Available from http://www.world-nuclear.org/info/inf84.html

Chapter Five
Attributes and options for renewable electricity technologies

5.1 Introduction

The previous chapter set out the justification for government support for large-scale renewable electricity technologies and argued that government adopted a politically convenient definition of renewable energy. This enabled the inclusion of technologies that are not necessarily renewable (waste, certain biomass) or emit low GHG emissions (certain biomass). This chapter sets out the reasons underlying the importance of the UK electricity sector with regard to meeting renewable energy and climate change objectives. It also examines the role of large-scale renewable electricity technology deployment to decarbonising the sector. With the need to replace around a quarter of UK power generation capacity over the next decade and the EMR reforms to provide broader support for renewable and low carbon electricity technologies, it is also relevant to investigate the role of low carbon energy with a particular focus on nuclear power.

Section 5.2 examines the role of large-scale renewable electricity technology deployment to decarbonising the sector. Section 5.3 analyses the resource potential of the various sources of renewable electricity. This will be carried out in order to understand the potential resource available and the implications this will have for specific renewable energy technologies. Building on the previous sections in this chapter, section 5.4 investigates and compare the key economic, technical, social and environmental attributes of the various renewable energy technologies in order to develop an understanding of the options available for the various RETs particularly with regard to their deployment within the overall electricity system.

5.2 The electricity sector and decarbonisation

The electricity sector in the UK is the single largest contributor to greenhouse gas emissions (GHG), contributing around 28 percent of total emissions in 2008 (Committee on Climate Change [CCC], 2010). Critically, on-going decarbonisation of the electricity sector is viewed as essential to meeting the UK's climate objectives as set out in the domestic Climate Change Acts: an 80 percent reduction in greenhouse gas emissions from 1990 levels by 2050 (for the UK overall, and at the national administrative level for Scotland), with diverging interim targets for 2020 (34 percent and 42 percent reductions on 1990 levels for the UK and Scotland respectively) (National Archives, 2008, 2009). Beyond 2020, the UK recently legislated to cut GHG emissions by 50 percent during the fourth carbon budget period (2023 to 2027) (Department of Energy and Climate Change [DECC], 2011a).[100] Climate change targets are also driven at the international level via the Kyoto Protocol and the EU's integrated energy and climate change 20-20-20 programme.

Two European Union directives (2001/77/EC and 2009/28/EC) have also set renewable energy specific targets for Member States, the former directive focusing explicitly on promoting renewable electricity (RES-E) generation whilst the latter directive set an overall legally-binding renewable energy target of 15 percent of total energy to be generated from renewable energy sources for the UK (incorporating the electricity, heat and cool and transport sectors) (Eur-Lex, 2001; Europa, 2009). This has been translated into a renewable electricity sectoral target of around 30 percent for the UK by 2020 (DECC, 2009a) whilst the Scottish Executive has recently increased the level of ambition for 2020 to a 100 percent equivalent RES-E target for Scotland (Scottish Government, 2011b) (for further information on renewable energy targets see chapter six, section 6.3).

---

[100] Although the UK Government agreed with the Committee on Climate Change's recommendation to cut GHG emissions by 50 percent for the fourth carbon budget, the UK Government ignored the committee's proposed indicative 2030 target of a 60 percent reduction in GHG emissions (CCC, 2011a; DECC, 2011a).

The electricity (or power) sector and not the heating and cooling or transport sectors has both historically and currently continue to remain the focus of much of policy and legislative effort in the UK.[101] In addition, these different targets, on the one hand for climate change and renewable electricity on the other, reveal that decarbonisation of the electricity sector is not assumed to be wholly dependent on renewable technologies. Under the overarching challenge of climate change, both renewable and low carbon energy technologies are expected to play a significant role in reducing climate-damaging greenhouse gas emissions. This is also reflected in the UK Government's non-legally binding low carbon electricity generation target of 40 percent by 2020, which incorporates the also non-legally binding RES-E sectoral target and government ambitions to encourage a programme of new nuclear build and develop four CCS plants at the demonstration level (DECC, 2009a). The key difference between renewable and low carbon electricity technologies in this respect is the fact that only renewable energy has a legally-binding target for 2020 established by the 2009 EU Directive, of which the RES-E sector is expected to play a critical role (DECC, 2009a). In contrast, the various climate change legislation do not set targets (volume or otherwise) for low carbon or renewable energy, and the UK low carbon target is merely anticipatory.

With specific regard to the renewable electricity sectoral target, this requires that renewable electricity supply technologies (RETs) be adopted. Renewable electricity supply technologies represent a distinctly heterogeneous category, incorporating many different technologies and fuels with very different attributes. In particular, a number of renewable electricity technologies do not conform to the characteristics of the current energy system (Woodman, 2008). The intermittent generators, including onshore and offshore wind, wave, tidal stream and solar PV are notable examples. Importantly, the level of conformity varies depending on the technology in question. It is necessary to analyse the differing economic, technical, social and environmental attributes of the

[101] This can be seen by the fact that there has been very little progress in the non-electricity sectors in comparison to renewable electricity generation (RES-E): in 2010, out of a total renewable generation output of 54 TWh, both the heating and cooling and transport sectors accounted for around 25 percent of total output each. In contrast, RES-E accounted for almost half of total renewable output in the UK (DECC, 2011c). Further, the Renewables Heat Incentive (RHI), a specific subsidy mechanism for the heat sector, was only implemented as recently as 2011 with full implementation scheduled for 2012 (DECC, 2011d).

various RETs, and how these technologies will sit within the wider context of the electricity and energy sector, particularly in terms of degree of intermittency of power supply and back-up requirements as well as flexibility of operation. There is also the issue of resource potential or '*renewable energy reserves*' to be taken into consideration. Importantly, they are at different levels of research, development and deployment, and such differing levels of maturity and market penetration will play an important role in whether and when they will evidence strong uptake by the market.

Decarbonisation of the electricity sector has a critical role with regard to transforming the UK into a low-carbon economy and to successfully meet the climate change targets for 2020 and 2050 enshrined in the domestic climate change legislation for the UK overall and, separately for Scotland (CCC, 2010a; Department of Energy and Climate Change [DECC], 2011e, f; National Archives, 2008, 2009; Scottish Government, 2011a). The electricity sector is also viewed as vital in order for the UK to meet the legally-binding EU renewable energy target of 15 per cent by 2020. This can be seen by a breakdown of the contributions of the three sectors towards the overall renewables target. Electricity generated from renewable energy sources (RES-E) is anticipated to provide the greatest share, 49 per cent (equating to the RES-E sectoral target of 30 per cent of total electricity generation) in contrast to 21 per cent and 30 per cent from the renewable transport and heat sectors, respectively (DECC, 2009b). Above and beyond these targets, however, electricity plays a fundamental role in virtually every aspect of modern life and is viewed as essential to economic and social wellbeing. As Laing and Grubb (2010: 2) put it

> "[Electricity] *is a high-grade energy carrier that is used in buildings, across industry and increasingly in transportation. It is both a final good that consumers buy – to power light bulbs, computers, fridges etc – and also an input into almost all industrial process.*"

This has led the Committee on Climate Change (CCC), the government's principal independent advisory body on climate change established by the Climate Change Act 2008, to recommend average emissions limits in power generation on the trajectory towards the 2050 climate change target: current average emissions of around

$500gCO_2/kWh$ should fall to approximately $300gCO_2/kWh$ in 2020 and $50gCO_2/kWh$ by 2030 (CCC, 2010).[102] In other words, the electricity sector should undergo early and radical decarbonisation. An examination of historical power sector emission trends serves to underline the radical nature of these targets in order to achieve such substantial sectoral decarbonisation. During the last two decades (from 1990 to 2010) power sector emissions have fallen below the current $500gCO_2/kWh$ on only two separate occasions, with the reasons for both due to extraneous reasons.[103] Between 1990 and 1998, emissions fell from around 770 to $490gCO_2/kWh$, primarily due to the restructuring of the UK electricity sector via privatisation and liberalisation resulting in investment of around 10GW of new gas-fired capacity which substituted for coal-fired generation (the so-called '*dash-for-gas*' period) (Helm, 2003). This was despite electricity demand growth averaging around 1.5 percent annually (CCC, 2010). The emissions intensity of power generation fell from 543 to $496gCO_2/kWh$ between 2007 and 2010, primarily due to the effects of the recent global economic crisis and the recession in the UK and abroad (CCC, 2010). In particular, between 2008 and 2009, the emissions intensity fell by 13 percent due to a reduction in demand due to the above reasons and an increase in nuclear generation as two plants returned to operation after outages in 2008, a reduction in coal-fired generation due to low gas prices and a small increase in renewable generation (CCC, 2011b). However, although the emissions intensity of power generation has fluctuated on a year-by-year basis since 1999, the emissions intensity has remained more-or-less constant at around $500gCO_2/kWh$. Therefore, although the CCC (2011a: 19) is basically correct when it stated that "*The underlying trend is a move to a less carbon-intensive mix*" this is only strictly accurate

[102] There appears to be tension between the CCC recommendation that the electricity sector be almost entirely decarbonised to $50gCO_2/kWh$ by 2030 (the central objective behind the rejected 60% cut in GHG emissions target for 2030 (see footnote 1). The Electricity Market Reform (EMR) document models a $100gCO_2/kWh$ by 2030 scenario (DECC, 2011f). The tension is due in large part to difference in the terminology used by the government: in contrast to the CCC's recommendation that the sector be 'almost entirely decarbonised' (CCC, 2011a, b), DECC has stated that '*To put us on this latter trajectory* [80 per cent carbon reduction target by 2050]*, power sector emissions need to be largely decarbonised by the 2030s.*' (DECC, 2011f: 5). These statements are completely different, particularly since the DECC position would lead to a higher UK electricity sector (and overall) emissions profile that the CCC is stating would be incompatible with the UK's carbon budgets.

[103] Extraneous reasons are defined here as due to factors other than those due to efforts to deal with climate change (incorporating measures to promote renewable energy and energy efficiency).

when looking at the trends from 1990 with the overall decline due to extraneous reasons. Importantly, the period from 1999 onwards, also coincides with the commencement of the majority of the UK Government's policy and legislative initiatives to address the issue of climate change (Freight Transport Association Limited, 2011).[104]

Although tensions remain between the government and the CCC regarding the desired level of emission intensity by 2030 (and beyond), consensus remains that the electricity sector faces significant cuts. One of the reasons why the power sector has been and continues to remain so significant is that it has consistently contributed the single largest source of emissions of any sector.[105] In 2010, total greenhouse gas emissions from all sectors equated to 590MtCO_2e, with the electricity sector accounting for 156MtCO_2e, or 27 per cent of the total (DECC, 2011e).[106] An examination of electricity sectoral GHG emissions reveals a similar trend to changes in the emission intensity of power generation. Although the overall trend between 1990 and 2010 has been one of decreasing emissions, from 204 to 156MtCO_2e, the sector has exhibited volatility for a number of reasons outlined above (CCC, 2011a). Electricity sector emissions fell by 28 per cent from 1990 to 1999 (from 204 to 147MtCO_2e). Between 2000 and 2008, however, emissions exhibited an overall increase underlined at times by annual volatility (from 159 to 172MtCO_2e) before dropping significantly between 2008 and

---

[104] Such initiatives include the adoption of the Kyoto Protocol and the first UK climate change targets (1997), the commencement of the UK climate change programme (2000), the Stern Review (2006), the launch of the Department of Energy and Climate Change [DECC] and the formation of the CCC (2008), the UK and Scottish Climate Change Acts (2008, 2009), the Renewable Energy Strategy (2008, 2009), the Low Carbon Transition Plan (2009), the Carbon Plan and Renewable Energy Roadmap (2011) and the Electricity Market Reform White Paper (2011).

[105] This parallels the increasing importance of electricity in the UK energy system. Between 1971 and 2007 electricity increased by 275%. This increased the sectors share of total final energy use from 8 %to 17% over the same period (Laing and Grubb, 2010).

[106] The basket of greenhouse gases covered by the Kyoto Protocol and domestic UK Climate Change legislation (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) are weighted by each gases individual global warming potential (GWP) in order to facilitate consistency in total GHG emissions reporting. The GWP for each gas is defined as its warming influence relative to that of carbon dioxide, with GHG emissions represented in carbon dioxide equivalent units (CO_2e) (DECC, 2011b). The baseline year of 1990 used in the domestic Climate Change Acts equates to 778MtCO_2e and the 2020 (34% for the UK) and 2050 (80%) reduction in GHG emissions equates to 513MtCO_2e and 155MtCO_2e, respectively [DECC, 2011b].

2009. Emissions fell by 13 per cent primarily (from 172 to 151MtCO_2e) as a result of the recession. As the UK temporarily moved out of recession in 2010, sectoral emissions increased slightly (from 151 to 156MtCO_2e). The current level of emissions from the electricity sector equates to the total level of greenhouse gas emissions permitted for all sectors across the UK under the 2050 targets for the domestic Climate Change Acts.

Despite being the single largest sectoral source of greenhouse emissions in the UK, electricity sector demand is expected to increase. The document '*2050 Pathways Analysis*' (DECC, 2010a), which presented a framework through which to consider some of the choices and trade-offs required over the next four decades in the transition to a low carbon economy, included a number of illustrative pathways to achieving an 80 percent emissions target while ensuring that energy supply would still meet demand. With the exception of the 'reference case' (which assumed little or no attempt to decarbonise and exhibited only a small increase in electricity demand), the remaining six pathways exhibited significant increases in demand for electricity. These ranged in increases from the current level of around 380TWh/year up to over 1,000TWh/year. The conclusion from the report, which the CCC (2010) agreed with in the '*Fourth Carbon Budget*' report, was that decarbonisation of the electricity sector may result in the requirement that supply may need to double by 2050. The reason for this increase, derived from the Pathways Analysis, is that

> "[A] *substantial level of electrification of heating, transport and industry is needed. Decarbonised electricity can be used for a wide range of activities… and can be scaled up to meet demand. It therefore makes sense to switch to electricity where this is practical, despite the major technological and engineering challenges involved….* [Although other non-electrified technologies may be required for heating and transport]*… some degree of electrification appears to be critical – analysis of alternative pathways shows that failing to at least partially electrify heating and transport would make the emissions target undeliverable unless very substantial demand reductions and technological breakthroughs were made and extremely large amounts of bioenergy were available.*" (DECC, 2010a: 34).

It should be noted, however, that the anticipated increases in both electricity demand and the contributions from the heating and transport sectors are only assumptions. Critically, although this shows that DECC is aware of the technological and engineering problems to large-scale RET deployment, this quotation appears to ignore the majority of the internal and external failures or barriers to such deployment in the UK. This is despite the fact that these have been shown to have a major negative impact on renewable deployment (this will be examined in more detail in Part III of the thesis). Importantly, these assumptions are also apparently based on another assumption, namely that the

> "[T]*he costs of reducing carbon-intensity in the power sector are generally lower than doing so in other sectors, and the least-cost path towards 2050 is therefore likely to involve early decarbonisation of electricity supply*" (CCC, 2010; 243).

In conjunction with the recommended cuts in emissions from the sector, the UK electricity sector is also undergoing considerable change that will have significant implications for the future. These changes include the projected loss of a sizeable proportion of the UK's current electricity generation capacity (the 'generation gap') and the on-going process of electricity market reform (EMR). There is also the planned growth in renewable and low carbon electricity supply technologies, with a new nuclear programme and the proposal to construct carbon capture and sequestration (CCS) power stations. Regarding renewable energy technologies (RETs), the vast majority of capacity, currently and proposed for at least the near future, are expected to come from intermittent wind power sources (including both onshore and offshore wind).

In particular, the on-going Electricity Market Reform (EMR) is the most major reform of the electricity market since the restructuring and privatisation of the sector that commenced with the enactment of the 1989 Electricity Act (Platchkov et al., 2011). Although the EMR will be examined in more detail in Chapter Seven, it is worth highlighting the key objectives underlying the reform process. As set out in the 2011 EMR White Paper '*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity*' (DECC, 2011f: 16) the primary objectives are to:

> "[1] *ensure the future security of electricity supplies;* [2] *drive the decarbonisation of our electricity generation; and* [3] *minimise costs to the consumer… The key to achieving these objectives will be to bring forward the level of investment needed in new low-carbon generation capacity and infrastructure at the required pace.*"

In other words, the EMR will be the main tool going forward to drive the decarbonisation of the electricity sector in order to meet the domestic climate change targets whilst maintaining security of supply. The package of policies proposed by the EMR, including a Feed-in Tariff Contract for Difference (CfD FIT) to financially support (subsidise) large-scale low carbon electricity technologies including renewables, nuclear and CCS, a Carbon Price Support (CPS) to underpin the current low carbon price via the EU ETS and address carbon price volatility, an Emissions Performance Standard (to limit the emissions intensity of electricity generation) and a targeted Capacity Mechanism (CM) to ensure security of supply are therefore designed with the objectives of the process in mind.

Currently around 75 percent of total electricity generation in the UK is generated from fossil fuel sources (coal, oil and gas). However, over the next decade "[The UK] *will lose around a quarter (around 20GW) of our existing generation capacity as old or more polluting plant close.*" (DECC, 2011f: 5).[107] Whether or not these closures results in a security of supply (capacity) gap, the scale of the closures forecast represents both a looming generation gap and an opportunity to fill the gap with renewable and low carbon generation technologies such as nuclear power and CCS in order to meet both the renewable and climate change targets for 2020 and to put the UK on a trajectory to meet the 2050 target of reducing GHG emissions by at least 80 percent from 1990 levels. Conversely, it also opens up the possibility for the construction of additional conventional generation. This will most likely be composed of gas-fired capacity. As with transmission and distribution infrastructure, electricity generation assets are typically capital intensive and long-lived, with the latter ranging from 20 to 50 years or more (Helm, 2003). Therefore, the type of technologies deployed now will have far-reaching consequences for the ability to decarbonise the UK electricity sector by 2030 and beyond: constructing more gas-fired capacity could lock-in the sector to a higher level of GHG emissions than recommended by the CCC. The key difference between

[107] Of the plant expected to close over the next 10 years, old plant refers primarily to nuclear power stations as they reach the end of their expected lifespan. Polluting plant refers to coal-fired capacity that will be required to close under the EU Large Combustion Plant Directive (LCPD) (Department for Environment Food and Rural Affairs, 2012).

renewable and low carbon energy sources in this respect, however, is the ability to deploy by 2020, the target deadline (which is the focus of this dissertation): there are valid concerns concerning both the government programme for new nuclear build and the demonstrative role of CCS by 2020.[108] In addition, any new nuclear plant constructed and operational by 2020 will have to be seen in the context of the scheduled closures of existing nuclear plant during the same period.[109] The limited ability of new nuclear and CCS capacity to meet this gap until post-2020 then leaves the generation gap potentially open to renewable energy technologies. The issue then becomes one not of technology 'choice' but rather whether or not renewable technologies will be able to do so or will other non-renewable and high carbon technologies deploy instead? This is significant for two major reasons: the sheer cost in terms of investment and the technical attributes of renewables, particularly given the current dominant role of intermittent, non-flexible wind power in the UK electricity

[108] Of the proposed 16GW of new nuclear build in the UK, plans for 6GW of new plant proposed at Wylfa and Oldbury have been withdrawn on 29 March 2012 by Horizon Nuclear Power (a joint venture between RWE and E.ON) (Guardian, 2011a) and there are delays in preparatory work at the proposed 3.2GW Hinkley Point site owned by EDF (Guardian, 2011b). Significantly, the chief executive of Centrica, which has a 20% stake in EDF's UK nuclear plans stated on 11 May 2012 that "*The investment case for nuclear has yet to be proven.*" (Daily Telegraph, 2012: 1) whilst Vincent de Rivaz, CEO for EDF highlighted that "*In particular, it is absolutely critical that the government continues to make steady, tangible progress with its Electricity Market Reform plans.*" (EDF, 2012: 4). Regarding CCS, the 4 year competition launched by the then Department for Business, Enterprise and Regulatory Reform (BERR) for industry to design, construct and operate the UK's first commercial-scale CCS demonstration project by 2014 with government funding of £1 billion was cancelled on 19 October 2011. The National Audit Office (NAO, 2012: 1) report '*Carbon capture and storage: lessons from the competition for the first UK demonstration*' provided a damning account of the UK governments role in the project: "*Four years down the road, commercial scale carbon capture and storage technology has still to be developed… DECC, and its predecessor* [BERR]*, took too long to get to grips with the significant technical, commercial and regulatory risks involved… Lack of clarity over government finance for the project delayed the early stages of the competition…* [and] *there was no agreement on government funding for operational costs.*"

[109] The planned lifetime of the UK's operating nuclear power stations are: Wylfa (2012), Hinkley Point B and Hunterston B (2016), Dungeness B (2018), Hartlepool and Heysham 1 (2019), Heysham 2 and Torness (2023) and Sizewell B (2035) (Nuclear Industry Association, 2012) (Nuclear Industry Association, 2012). Interestingly, Charles Henry, the Minister of State for the Department of Energy and Climate Change indicated in February 2012 that existing nuclear reactors were likely to have their operational life-spans extended beyond the mid-2020s in order to tackle the looming electricity generation gap, thus providing more time for new low carbon capacity to be built and to address the fact that "*The UK's deregulated electricity market had not produced enough capacity to replace the fossil fuel and nuclear plants that are due to be switched off over the next 10 years.*" (BusinessGreen, 2012: 1). Although strongly against new nuclear build in Scotland, the current Scottish National Party (SNP) led administration signalled as far back as July 2011 that the SNP were perfectly open to extending the life of Scotland's two nuclear plants at Torness and Hunterston (Guardian, 2011c).

generation landscape up to 2020 and beyond (the technical attributes of electricity supply technologies will be looked at in more detail in section 5.4).

5.3 Renewable energy reserves

From the previous section, it is clear that the UK Government has focused on the electricity sector with respect to the twin objectives of the overarching climate change target for 2050 under the domestic climate change legislation and the EU renewable energy target for 2020. With regard to the 2020 target, electricity generated from renewable sources (RES-E) will shoulder the burden of total renewable generation: 50 percent, equivalent to 30 percent of total UK electricity generation or approximately 114 TWh (DECC, 2009b). Significantly, there is no guarantee that the amount required by the renewable electricity sector will remain at this level as the UK progresses towards the 2020 target.[110] This means that an understanding of the potential resource base is therefore critically important for a number of reasons, including renewable-specific targets that are both ambitious and demanding within a short timetable and the relatively limited experience in developing and deploying renewable energy technologies to utilise such resources, especially in the case of offshore RETs. Such an understanding of the type, availability and requirements of the energy resource in question has implications for policy decisions regarding which technologies could be the most suitable or capable of delivering the targets. There are also the associated benefits that could be accrued from gauging the full scale of the opportunity the successful adoption of those technologies can entail.

Two of the major differences between renewable and non-renewable energy sources (including uranium as well as oil, gas and coal) concern the issues of resource geographical distribution and resource potential or 'reserves'. At the global level, renewable energy resources are significantly more wide-spread geographically in comparison to non-renewable sources: virtually every nation has at least some reserves

[110] The share of the burden could increase depending on future electricity demand in addition to energy efficiency measures and the level of success in developing the renewable heat and transport sectors.

of renewable energy resource, whether terrestrial, marine or a combination of the two (Renewable Energy Policy Network for the 21st Century [REN21], 2011). This is in stark contrast to non-renewable sources of energy.[111] Such reserves, by the very definition of what constitutes a source of renewable energy, are also temporally infinite. Whereas fossil fuel and nuclear energy sources are non-renewable and finite (at least over any meaningful time-scale) and therefore will eventually run out at some point in time, renewable reserves are naturally and constantly replenishing.[112] As Chapter Three showed, however, renewable energy sources can be broadly categorised into two main groups based on whether the resource can return to previous levels by natural processes of replenishment or growth after exploitation (such as solar, wind, marine and hydropower) or where the rate of replenishment and exploitation requires appropriate management (such as biomass, and including hydropower under certain conditions such as excessive water exploitation for other purposes or periods of drought).[113]

Table 5.1 (page 140) provides an assessment and analysis of the extent of wind power, marine power, hydropower, solar photovoltaic and geothermal renewable energy resource availability in the UK from four major studies. When determining resource availability, however, it is important to clarify two major points: the use of definitions and methodologies in the four studies shown in Table 5.1, and what will be termed here '*the hierarchy of final resource utility*'. Regarding the first point, although these studies were chosen due to the reason that they examined the practical resource of the major renewable energy sources, the precise definition differs between the reports. In general, "*the practical resource is what is available after consideration of external physical*

---

[111] However, estimates of shale gas in the UK (and abroad) could force a revision of this, in addition to the recent increases in the number of licenses offered for conventional oil and gas exploration and exploitation.

[112] This could mean that the resource is physically depleted. The more likely scenario, at least for the foreseeable future, is that the resource could be depleted to such an extent that economic or technical issues limit resource availability or access to the resource.

[113] Although non-waste biomass sources could replenish naturally and thus return to pre-exploitation levels, the issue becomes one of time management in order for the resource to be available constantly given the growth rates required for many sources of non-waste biomass.

Table 5.1 Estimates of terrestrial and marine renewable energy resource availability in the United Kingdom

	Wind power		Marine power			Hydropower		Other	
Source	Onshore wind	Offshore wind	Tidal stream	Tidal range	Wave	Hydro reservoir	Hydro run-of-river	Solar PV	Geothermal
Committee on Climate Change [CCC, 2010]	74 TWh/y [1]	405 TWh/y	116 TWh/y [3]	44 TWh/y	40-50 TWh/y			140 TWh/y	35 TWh/y
2050 Pathways Analysis [DECC, 2010a]	74 TWh/y [1]	430 TWh/y [2]	>197 TWh/y [3]	50 TWh/y	50 TWh/y	12 TWh/yr [4]		140 TWh/y[5]	35 TWh/y
Arup [Arup, 2011]	57 TWh/y[6]	181 TWh/y[7]	18 TWh/y	-	50 TWh/y	~ 5 TWh/y [8]		20 TWh/y [9]	32 TWh/y
Offshore Valuation Group [OVG, 2010]	-	1,939 TWh/y [10]	116 TWh/y	36 TWh/y	40 TWh/y			-	-

Note: All estimates of resource availability are based on 'practical' resource availability for the UK (see text for definition). Estimates also include existing generation output as of 2010. All offshore wind studies include data from fixed offshore wind turbines only. [1] Based on 28 GW installed capacity with 30% load factor. [2] Based on 140 GW installed capacity with load factor assumed at 35%. [3] Due to ongoing controversy around the correct physical method for estimating tidal stream resource the range of estimates varies from 18-197 TWh per year. [4] Based on 4 GW installed capacity with load factor of 38%. [5] Based on maximum possible deployment of solar PV panels installed on south facing roofs and facades only. [6] Only looks at onshore wind with an overall installed capacity greater than 5 MW. Based on 23 GW installed capacity with load factor of 28%. [7] Based on 51 GW installed capacity with a load factor of 40%. [8] Untapped hydro resource (at greater than 5 MW installed capacity) estimated to be nearly fully utilised (+122 GWh or 38 MW installed capacity with a load factor of 36.7%. [9] Based only on solar PV with an installed capacity greater than 5 MW. [10] Includes estimates of floating offshore wind technology.

constraints, therefore excluding areas due to conflicting uses" (Offshore Valuation Group [OVG], 2010: 32). This should include, for example, environmental, ecological or heritage-sensitive sites and competing uses (such as shipping, fishing, oil and gas extraction and existing renewable leases)[114]. The definition of what constitutes a practical resource can vary, then, depending on the level of analysis (such as how many constraints of this type are incorporated). It can also differ due to inclusion of issues of economics, an important factor given the currently higher costs of renewable energy technologies in comparison to conventional generation technology and the relative immaturity of the majority of RETs resulting in a lack of experience particularly in terms of deployment and operation and maintenance issues, and the timeframe for exploitation: in contrast to the other reports that examine resource availability up to 2050, the Arup (2011) report set a 2030 deadline. Different methodologies can also result in contrasting estimates. For example, some reports omit certain renewable energy technologies whilst others include additional ones.

Crucially, there are a number of barriers or constraints that act on actual real-world deployment rates with the result that it is highly unlikely that estimates of practical resource availability will translate into the level for installed capacity and generation output put forward in the reports analysed here. The conventional method of determining the potential renewable resource base by analysing the theoretical, technical, practical and economic resource 'reserve' is only the first step in determining the final or real-world deployment potential of those technologies and infrastructure required to make use of the resource reserve. As such, any proclamations of the UK's renewable energy resources will rarely if ever translate with any level of fidelity into an amount consistent with such public declarations.[115] The second step or stage of the

[114] This is in contrast to the theoretical resource which covers the total energy available for the entire resource type excluding any constraints or barriers to extraction. The technical resource constrains the theoretical resource based on technology-specific limitations, including suitable siting, conversion efficiency, and load factor and power density. The economic resource narrows the practical resource by taking cost considered to be economic (but this judgement is subject to change over time) (OVG, 2010).

[115] For example, the First Minister of Scotland, Alex Salmond has repeatedly stated "*Our potential for electricity generation from renewables is up to 60 GW – more than ten times our peak demand*" (Scottish Government, 2009a: 1) and that "*… it is estimated that we could meet our country's own energy needs five to ten times over, from renewable sources alone*" (Scottish Government, 2009b: 1). Indeed, the Pentland

hierarchy includes those barriers or constraints termed the internal or external failures, including subsidy mechanism design, planning, grid, investment, policy uncertainty and public opposition that can and do limit the actual exploitation of the resource in reality in terms of deployment level. Critically, none of the categories to estimate resource potential (theoretical, technical, practical and economic) incorporate such constraints to renewable deployment. This will also be the case for analyses of deployment rates that do not take into consideration the full range of such constraints, particularly from a systemic approach. The impact of the internal and external failures on renewable deployment levels will be examined in detail in Part III – Adopting the Systemic Approach. This could have significant policy implications: the '*The Offshore Valuation: A valuation of the UK's offshore renewable energy resource*' report states that the utilisation of 76 percent of the practical offshore renewable resource "*would provide 50 percent of UK electricity demand and just over a quarter of EU electricity demand* [both by 2050]" (OVG, 2010: 21). In context, this would equate to 1,610 TWh per year, more than the estimated projections for total energy consumption in 2020 of 1,590 TWh (DECC, 2011g).

As Table 5.1 shows, the focus is on the potential available resource for the different renewable sources based on what is practical (the practical resource) and therefore arguably the largest amount before taking into account other limitations. It is clear from all four studies that wind power provides the largest practical resource, with offshore wind providing the greatest share. The substantial difference between the OVG and the other three reports (1,939 TWh compared to over 400 TWh per year) is due to the inclusion of the floating offshore wind resource in addition to the fixed resource. Primarily at the design and prototype stage, with only two full scale devices deployed, the potential for this new variant of offshore wind is highly significant with an estimated total resource of over 1,500 TWh[116]. However, almost half of this resource

Firth, one of the sites for marine renewables, was described by Alex Salmond in 2008 as the 'Saudi Arabia of marine energy' (BusinessGreen, 2008:1).

[116] In 2009 Statoil Hydro deployed a 2.3 MW floating device in the North Sea, in 722 feet of water depth and 7.4 miles from the coast. In 2012, a 2 MW floating turbine was towed over 200 miles off the Portuguese coast into the Atlantic Ocean at a water depth of 35 metres (Power, 2012).

(660 TWh per year) of this is located beyond 100 nautical miles (nm), which could be unfeasible due to the distance from shore and logistical and economic issues concerning maintenance (OVG, 2010). This still leaves over 400 TWh per year of offshore fixed wind resource[117], almost four times the amount required to meet the UK's 2020 RES-E sectoral target and nearly double the total renewable target of 15 percent equating to 234 TWh in 2020. Critically, this resource would be available continuously, year by year, in contrast to conventional energy sources.[118] Although significantly less, the onshore wind practical resource still represents an additional 68 TWh per year by 2050 in addition to current output levels in 2011 of over 10 TWh which equates to almost 5 GW of installed capacity (see also chapter six, table 6.1). In other words, the practical resource is approximately equivalent to ten times current resource exploitation. Based on an installed capacity of 28 GW, when compared with the density of onshore wind farms in Denmark (MW per 1000km^2), a country renowned for onshore wind deployment, DECC's '*2050 Pathways Analysis*' report estimated the total practical capacity could be around 16 GW. In contrast to the resource reserve size stated above, this would mean that there is only 10 GW of potential future installed capacity remaining in the UK, a significant reduction given that onshore wind currently dominates and drives UK RES-E deployment towards the 2020 target (see chapter six).

For the marine renewables, there is a consensus over the total practical resource with wave power at between 40-50 TWh per year and tidal range ranging from 36 to 50 TWh per year (the OVG report examined less potential sites than the other reports that examined tidal range power). The tidal range resource, however, is heavily dependent on the inclusion of the Severn barrage proposal which is estimated to generate around

---

[117] The difference between the Arup (2011) study and the CCC (2010) 'Fourth Carbon Budget' and the '2050 Pathways Analysis' (DECC, 2010a) reports is due to the former report looking out to 2030, twenty years less than the latter two reports. This also accounts for the difference between these reports for onshore wind and tidal stream power (see below).

[118] In contrast, non-renewable energy sources would require additional new resource sites to be located and developed in order to maintain increases in resource availability for exploitation. As the time-frame for hydro-carbon based sources is geologically slow, ultimately this would see a decline in resource availability over time. Indeed, many argue now that such a peak has already been reached or will be in the near future.

16 TWh per year.[119] The variation in tidal stream resource (18 to >197 TWh per year) reflects uncertainty in the underlying methodology and the assumptions used to estimate this resource. It is likely that the tidal stream resource will be the largest of the marine energy sources, at over 100 TWh per year (CCC, 2010; DECC, 2010a; OVG, 2010).

The practical resource availability estimated for geothermal is consistent across the three studies that examined it, at between 30-35 TWh per year. In contrast, solar photovoltaic estimates range from 140 TWh (CCC, 2010; DECC, 2010) to approximately 20 TWh per year (Arup, 2010). The reason for this considerable discrepancy is primarily due to the inclusion of economic factors to the ARUP estimates and the cut-off date of 2030. Only two studies analysed hydropower, providing a significant range in estimates of between approximately 5 TWh (Arup) to 12 TWh (DECC) per year. Given that hydropower output already stands at around 5 TWh in 2010 (see Chapter Six), this means that there is either no further site availability or there is over twice as much as currently exists in the UK. The difference in resource estimates appears due primarily to the DECC report taking into account a number of studies that show that the remaining hydropower resource is between 900 MW to 2.4 GW by 2050. Although this again represents a significant variation in estimates, either way it can be argued that hydropower (unlike the other sources) will not play a critical contribution to meeting the targets in terms of renewable resource size. However, in contrast to the other renewable sources examined in Table 5.1, hydropower is a non-intermittent energy source that could play a critical role in balancing those sources which have larger practical resource potential but are intermittent.

In addition to looking at estimates of renewable energy availability, it is also necessary to determine where the resources are specifically located: in other words, where are the best reserves geographically? This will have particular implications for the deployment of the different renewable energy technologies (for example, planning and grid issues

[119] Although resource estimates showed that the Severn scheme could provide up to 5 percent of the UK's current electricity generation, in October 2010 the UK Government rejected the scheme for a number of reasons, including high cost (as much as £34 billion) as well as investment and environmental issues (DECC, 2010b).

and public attitudes to renewable energy deployment). Figures 5.1 and 5.2 (pages 146-147 and pages 148-149, respectively) graphically represent the geographical distribution of the major terrestrial (onshore wind, solar and biomass) and marine (offshore wind, wave, tidal stream and tidal range) resources in the UK. As expected, part A of Figure 5.1 shows that annual mean wind speeds are highest in the upland and mountainous regions of the UK (Scotland, Wales and North-West England). Overall, the geographical distribution of the onshore wind resource is overwhelmingly concentrated in Scotland (in terms of the best wind resource, highest speeds). South-East England, where the majority of the UK population reside, exhibits far lower annual resource. The reverse is true for solar photovoltaic (Part B) where the highest level of solar radiation occurs in the south-western parts of the UK and to a lesser extent in the South-East. Part C and D look at the non-waste biomass resource distribution and potential for Scotland and the UK, respectively.[120] Showing total current biomass resource (including forestry, short rotation crops and energy crops), Part D illustrates that the lowland areas of the UK, concentrated primarily in England and to a significantly lesser extent on the eastern coastal lowlands of Scotland, represent the geographical distribution of non-waste biomass resources. When the potential future biomass resource (utilising temporary, permanent and rough grazing) is included, this would approximately correspond to the areas showing least current biomass resource (the area corresponding to <5,000 oven-dried tonnes, ODT). Incidentally, this is also the area of best wind resource (see Part A of Figure 5.1). Although excluding agricultural land that could be used for biomass resources, the ‘yellow’ area corresponds closely to agricultural (arable) land (Scottish Government, 2011c).

Part A of figure 5.2 reveals that the highest annual mean wind power density (in Watts per square metre, or W/sq m) is strongly concentrated (from 1,501 W/sq m to > 2,500 W/sq m) off the west coast of Scotland, stretching out over 800 miles into the northern

[120] The analysis of the geographic distribution of biomass resource (current and future) is not meant to be exhaustive, rather to illustrate the approximate location of the major resources. Waste biomass resources are excluded.

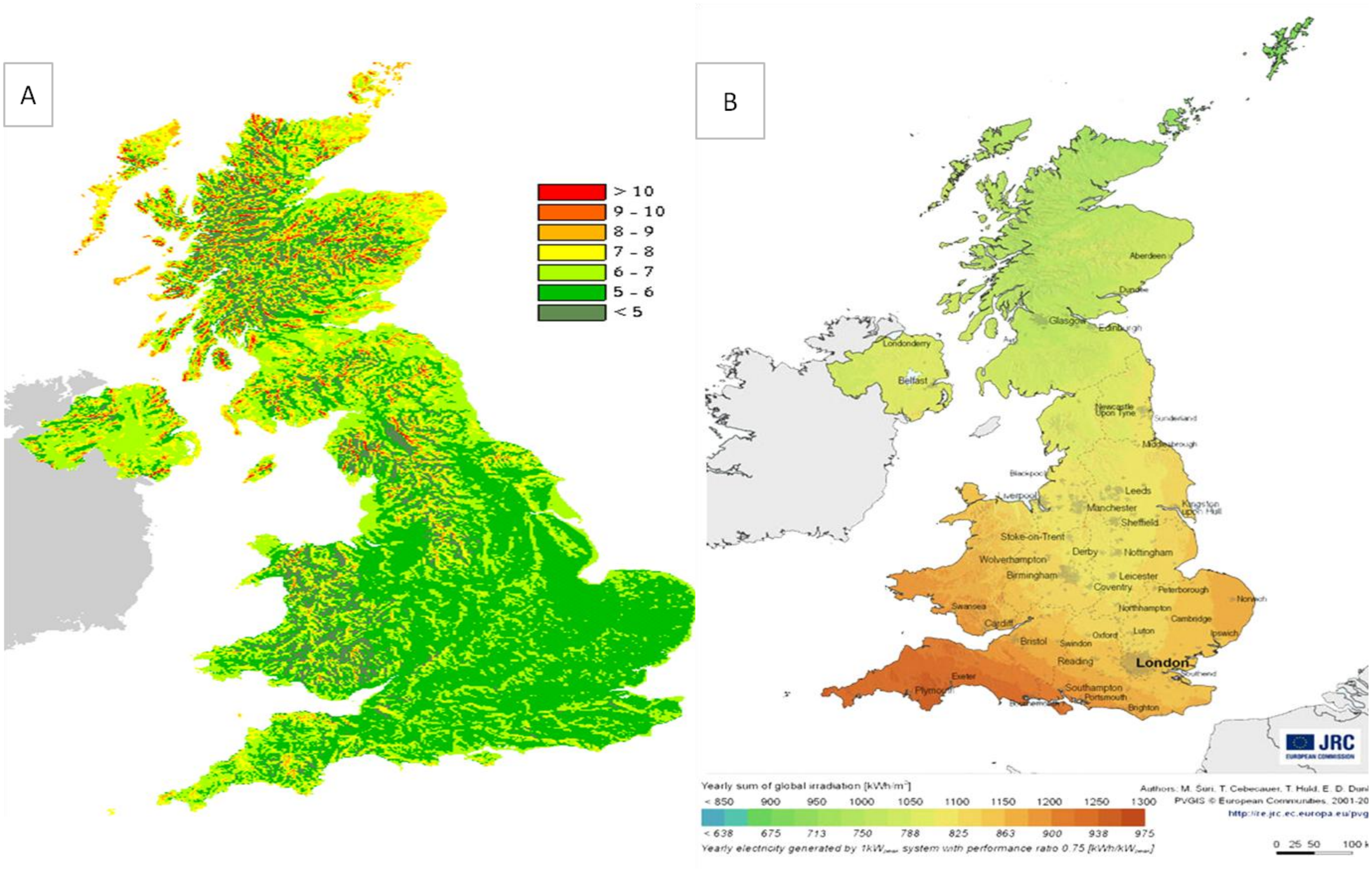


Figure 5.1 Terrestrial renewable energy resources in the United Kingdom for onshore wind power (A) and solar radiation (B).

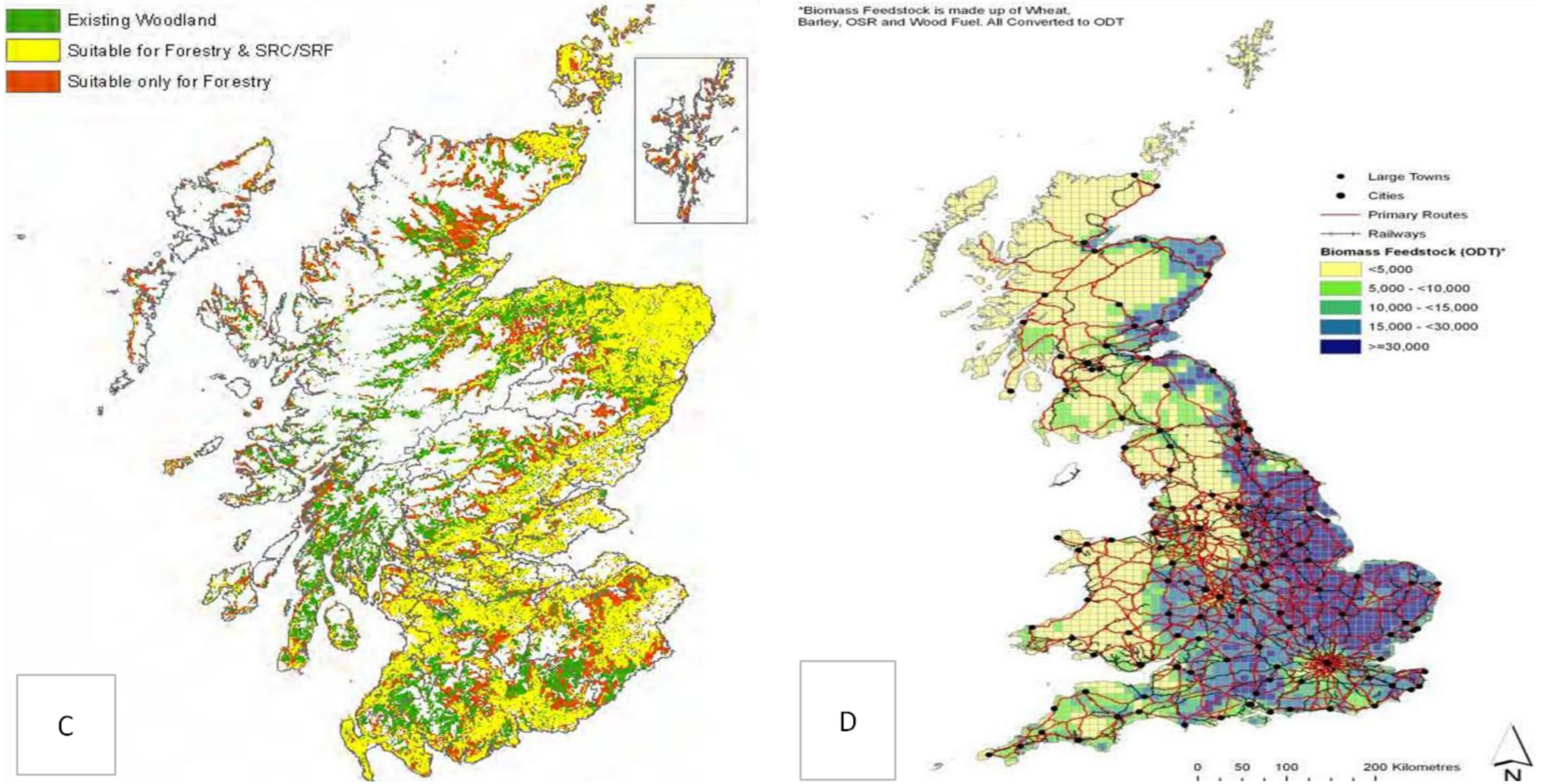


Figure 5.1 (Cont) Biomass in Scotland (C) and the United Kingdom (D).

Note: (A) Annual mean wind speed at 25m above ground level (m/s) (Energy Systems Research Unit, 2011). (B) Solar radiation (kWh/m²) (Šúri et al., 2001). (C) Suitable land for biomass crops (woodland, forestry, short rotation coppicing and short rotation forestry). Although the map excludes agricultural land used for biomass (energy) crops the yellow area corresponds to agricultural land (Scotland & Northern Ireland Forum for Environmental Research [SNIFFER], 2010: 55). (D) UK current biomass availability (in oven-dried tonnes), transport infrastructure and urban conurbations (Department for Environment, Food and Rural Affairs [DEFRA], 2008: 56).

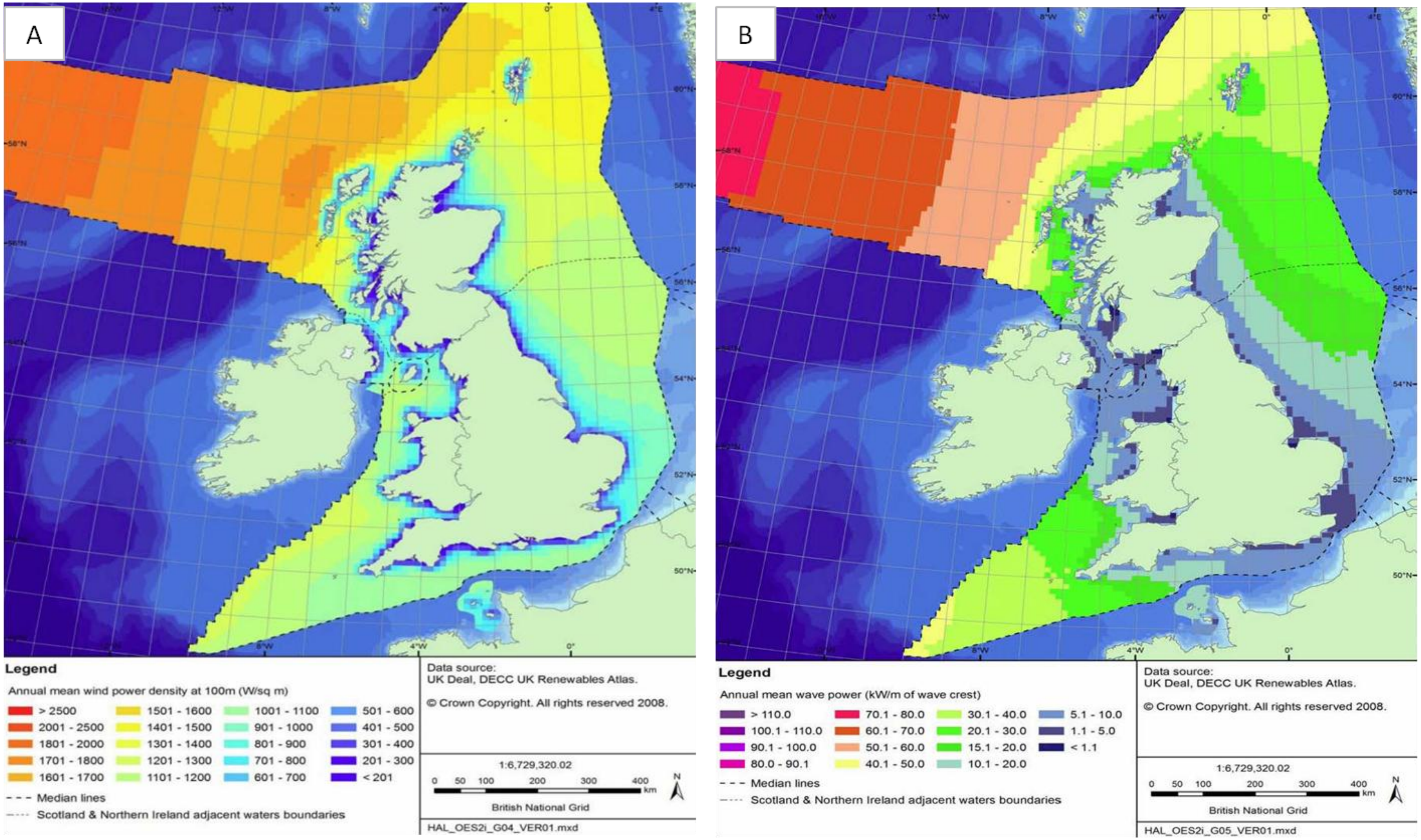


Figure 5.2 Marine renewable energy resources in the United Kingdom for offshore wind power (A) and wave power (B)(DECC, 2011f).

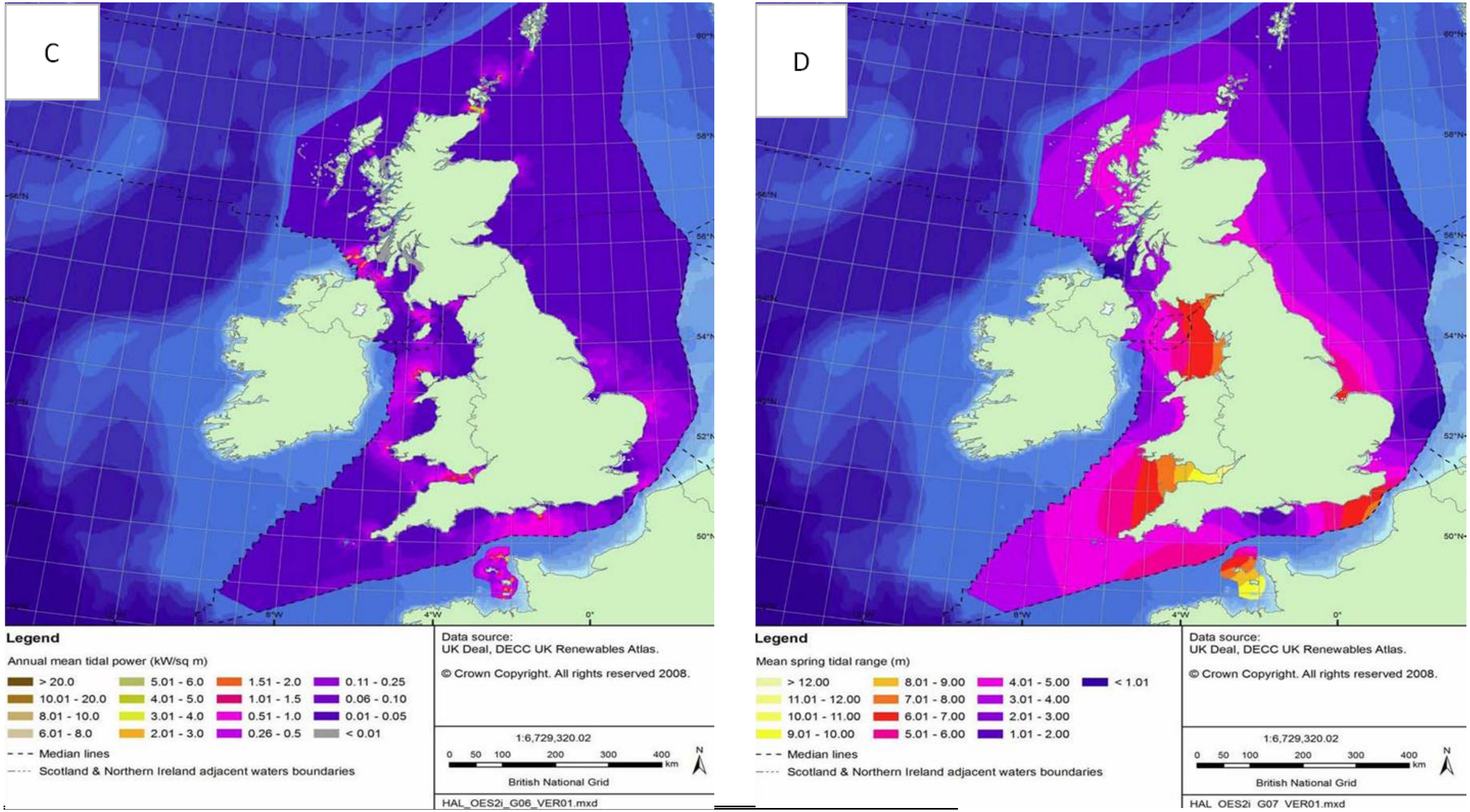


Figure 5.2 (Cont) Tidal stream (C) and tidal range (D) (DECC, 2011f).

Note: (A) Annual mean wind speed power density at 100m (W/sq m). (B) Annual mean wave power (kW/m of wave crest). (C) Annual mean tidal stream power (kW/sq m). (D) Mean spring tidal range (m).

Atlantic Ocean with the best resource furthest from the mainland. Away from the coast, the total wind resource over a given year is relatively uniform across very large areas, although both occurrence and strength of wind is dependent on meteorological factors (DECC, 2011g). At the gross overall scale represented in Part A, in comparison the offshore wind resource for the rest of the UK (meaning Wales and England) is substantially lower: in terms of power density, it is at least 1,000 W/sq m less and only if the Scottish resource is utilised closest to the mainland. Importantly, it appears that within the 12 nautical mile zone (the territorial waters designation) the offshore wind resource is less than 700 W/sq m. In general, the geographical distribution of the UK's wave resource (Part B) is similar to that of offshore wind with the UK wave energy resource broadly concentrated to the west of Scotland, although there is a noticeable though less significant resource concentration around the South-West peninsular (Cornwall), particularly if wave devices are deployed further from the Scottish mainland, for example west of the Outer Hebrides. Part C shows that the UK tidal stream resource is more geographically constrained in comparison to offshore wind and wave, being localised around headlands and through straits between land masses. The tidal range resource shows similar geographical constraints, limited as it is to various estuaries and bays such as the Severn, Mersey and the Solway Firth (Part D).

5.4 Attributes of renewable energy technologies

Renewable electricity supply technologies represent a distinctly heterogeneous category. At the technology level there are six major 'families' and associated sub-categories: wind power (onshore, offshore), marine (wave, tidal stream, tidal range), hydro power (small-scale, large-scale), biomass (landfill gas, sewage gas, co-firing and other biomass), solar photovoltaic (off-grid systems, grid-connected systems) and geothermal (natural hydrothermal, geopressured systems, hot dry rocks, magma, low-grade heat pumps).[121] RETs incorporate many different technologies and fuels with very

[121] This is a list of actual technologies irrespective of stage of development or whether or not they currently generate RES-E in the UK. The sub-categories could be further broken down, for example, wave power includes: wave shoreline, wave near shore (less than 20 miles to the coast) and wave offshore. For a detailed explanation of the technical aspects of the various technologies and associated sub-categories see Boyle, 2004.

different characteristics. Such technologies are typically long-lived assets, with operational life-spans ranging from twenty to fifty plus years, although there is considerably uncertainty with regard to those relatively untested technologies lacking any real or significant deployment history. This is particularly the case for marine RETs and offshore wind. Not all technologies or fuels are limited to the electricity sector. Biomass can also be used in the heating and cooling and transport sectors, and such end-use flexibility can lead to conflict or sectoral prioritisation over utilisation, particularly as the non-renewable electricity sectors are under-performing in comparison to the electricity sector. Importantly, they are at different levels of research, development and deployment. This can also be the case at the sub-category level for technology types (for example, wind power). In any given time period, there will be those technologies that can contribute towards the renewable (or low-carbon) targets and those on the horizon that require more research, support and time in order to reach deployment at the scale required. Such differing levels of maturity and market penetration will play an important role in whether and when they will evidence strong uptake (pull) by the market.

Table 5.2 (pages 152-153) shows the key economic, resource, technical and environmental attributes of the major renewable, low-carbon and conventional fossil-fuel technologies in order to help clarify and understand the options for the various renewable electricity supply technologies. With regard to the economic attributes, the UK's technological options in respect to the stage of technological development (or technology maturity) can be broadly classified into four groups: the methodology used here is adapted from Jamasb *et al* (2008). The first group, RD&D (research, development and demonstration) includes early prototypes and installed full-scale working devices only deployed in single units or small numbers, largely financed through R&D-related grants.[122] The second group, pre-commercial is the stage where multiple units are installed for the first time and/or where the first few multiple units

---

[122] Those technologies at the purely R&D stage are usually categorised into a prior group, including both 'blue skies' science and engineering and application-focused research (Jamasb *et al*., 2008). Examples of such technologies include novel (non-conventional) solar PV, some geothermal technologies, CCS and the next generation of nuclear reactors (nuclear generation IV).

Table 5.2 Attributes of key renewable, low-carbon and conventional electricity technologies

Technology	Stage of development	Resource potential	Level of intermittency	Flexibility of operation	Back-up	Environmental (GHG/pollutants)
Renewable technologies						
Onshore wind	Supported commercial	Infinite	High	Non-flexible	Yes	Low
Offshore wind	Supported commercial	Infinite	High	Non-flexible	Yes	Low
Marine	RD & D	Infinite	Medium [1]	Non-flexible	Yes	Low
Hydro	Fully commercial	Infinite - M	n/a	Flexible	No	Low
Geothermal	R & D	Infinite	n/a	Flexible	No	Low
Biomass	Combustion: Fully commercial	Infinite - M	n/a	Flexible	No	Low - High [3]
Low-Carbon technologies						
Nuclear	See text	Finite	n/a	Non-Flexible	No [2]	Low [4]
CCS	See text	Finite	n/a	Flexible	No	Medium
Fossil Fuel technologies						
Coal	Fully commercial	Finite	n/a	Flexible	No	High
Oil	Fully commercial	Finite	n/a	Flexible	No	High
Gas	Fully commercial	Finite	n/a	Flexible	No	High

Note: Stages of development are taken from Jamasb *et al* (2008). However, categorisation of technologies into stages reflects data as of 2011. Infinite-M = a renewable resource where exploitation requires management in order that the resource can replenish itself over an appropriate timescale without risk of depletion. [1] Although intermittent, marine renewable energy technologies (wave, tidal range, tidal stream) are more predictable than other intermittent renewables due to the nature of the resource. [2] The number of unplanned outages of UK nuclear power stations, often around 1 GWe in size can cause significant problems for the electricity grid network and thus arguably require more back-up generation than renewables (Toke, 2011; see text below and chapter four, section 4.3). [3] Due to the diverse range of technologies and fuels subsumed in the overall biomass category in addition to other factors such as land-use change some exhibit low, medium or high GHG emission profiles. There are some reports that suggest that biomass lifecycle emissions could be far higher than assumed, potentially as high as some forms of fossil fuel generation (see text below and chapter four). [4] There are some valid concerns over the GHG emissions profile of nuclear due to lifecycle complexity, decommissioning inexperience and future uranium ore grade (see chapter four for further analysis).

Table 5.2 (Continued)

Technology	Scale	Geographic dispersal	Plant size	Landscape impact [1]
Renewable technologies				
Onshore wind	S - M	High	High	High
Offshore wind	M - L	Very High	Very High	Medium - High
Marine	?	Medium - Very High	Very High	?
Solar PV	S	Very High	Small	Low
Hydro	S - M	Low	Small - Medium	Low
Geothermal	?	?	Small	Low
Biomass	S - M - L	Low	Small	Low
Low-Carbon technologies				
Nuclear	M - L	Low	Small	Low
CCS	M - L	Low	Small	Low
Fossil Fuel technologies				
Coal	M - L	Low	Small	Low
Oil	M - L	Low	Small	Low
Gas	M - L	?	Small	Low [2]

Note: ? refers to where there is insufficient data and/or analysis to date. Primarily this means that there is little or no deployment experience or research currently carried out. [1] The information contained within this category is not fully established due in part to limited current research and can be argued to be at times subjective. However, the general nature of the data dealt with in this table is fairly robust under the assumptions provided (see text). [2] In the case of shale gas, there is a growing body of research indicating potentially significant problems with shale gas, including causing earthquakes and possible groundwater contamination although both issues are currently thought to be low risk (Energy and Climate Change Committee, 2011a; The Royal Society and The Royal Academy of Engineering, 2012). It should be pointed out, however, that there are opposing points of view (see 'Shale Gas: Fifth Report of Session 2010-12: Volume II: Additional written evidence, Energy and Climate Change Committee, 2011b).

move to much larger-scale deployment for the first time. The third group, supported commercial is the stage where technologies are rolled out in substantial numbers and by commercially orientated companies. The fourth group, fully commercial represents technologies that can compete unsupported. In comparison to both supported and pre-commercial, technologies in the fourth category do not require some form of generic support (such as the UK Renewables Obligation). This is the stage where it is envisioned that such technologies can compete in the wider market without the support of the protected domain.

It is clear from Table 5.2 that the major fossil fuel technologies including coal, gas and oil are all fully commercial, reflecting established histories of operational experience and deployment. The situation for low carbon technologies is not so simple. As with large-scale renewable electricity technologies, the low carbon category represents a number of different technologies at varying stages of development. Further, it is difficult to argue that existing nuclear power technologies, including generation II advanced gas-cooled reactors (AGRs) and pressurised water reactors (PWRs) already operating in the UK and abroad are fully commercial. Although existing nuclear power technologies do not currently receive any state subsidy on the basis of generation output (in contrast to renewable electricity technologies), they do receive other subsidies in the form of decommissioning, insurance liabilities and public bailout.[123] There are also a number of new generation nuclear technologies either poised for commercial deployment (generation III) or at the R&D stage (generation III+ and IV). Dependent on a decision on state aid rules, new build nuclear stations will also be eligible for state subsidies under the CfD FIT mechanism (on a generation output basis) alongside loan guarantees. Regarding CCS, many of the technologies and processes are already fully commercial but either at small-scale (shipping) or developed for application in other areas (pre-combustion technology widely applied in fertiliser manufacturing, post-combustion technology in separating carbon dioxide in natural gas processing). In contrast, oxy-fuel

[123] In 2005 the UK government had to bail out British Energy at a cost of around £5 billion. In addition, nuclear power received state subsidies for a limited time period under the NFFO (see chapter three, section 3.3).

technologies for CO_2 capture are at the RD&D stage whilst CO_2 storage, with the exception of use for enhanced gas or oil recovery, is at the supported commercial stage.

Focusing on the renewable energy technologies, only two of the seven major technology families are either at the fully commercial stage of development or evidence technologies at that stage: hydro power and specific biomass RETs. As with the majority of the non-renewable technologies, hydro power also has a long history of deployment in the UK (Grubb and Vigotti, 1997). With regard to biomass, it is only really the thermal processing of biomass (combustion) to generate electricity that is at this stage, although there are a number of technologies included in the gross biomass category that fall within the other stages representing less mature options (see below). The next stage of development, the supported commercial stage, includes the sub-categories of wind power and conventional solar photovoltaic. In contrast to onshore wind, which can be viewed as being situated at the boundary between supported and fully commercial (particularly those wind farms or turbines located in the areas of best wind resource), offshore wind is a recent addition to the supported commercial stage. In 2008 offshore wind was categorised at the pre-commercial stage, reflecting the level of limited deployment shown only three years ago (Jamasb *et al.,* 2008). There are a number of reasons for the differences between onshore and offshore wind, including the technological maturity of onshore wind turbines due to research and deployment over the last three or more decades in countries like Denmark and Germany (where most of the turbine manufacturers are based). Despite the apparent visual similarities between the two RETs, offshore wind faces considerable challenges not least with regard to the foundations and the significantly more severe marine environment around the British Isles. However, the fact that both technologies now fall within the supported commercial category is an indication of the political motivation behind wind power in the UK, evidenced by the subsidy level set through the RO. With the introduction of technology banding into the RO mechanism in 2009, offshore wind was initially allocated 1.5 ROCs per MWh output. Offshore wind was then temporarily banded-up to 2 ROCs per MWh (DECC, 2009c).

Significantly, there are no renewable energy technologies currently at the pre-commercial (third) stage, although there are a number of technologies at the boundary between RD&D and pre-commercial such as tidal barrage and biomass gasification which are related to technology types already at the supported commercial stage or above. In contrast, the major marine renewable technologies are all currently designated within the RD&D (fourth, or least technological mature) stage, and as such will continue to require substantial public support in the long term. Within this stage, wave and tidal stream RETs are less technological mature than tidal barrage. Other technologies at this stage include biomass gasification (such as anaerobic digestion), nuclear generation III+, and natural hydrothermal geothermal technologies.[124] In terms of long-term future potential technological diversity, there is a particularly wide range of RET options of fundamentally different technologies within the R&D, RD&D and pre-commercial stages.

The first column of Table 5.2 shows, then, that some renewable energy technologies can be said to be ‘more ready’ than other technologies. This reflects in part the level of technological risk or perceived risk by the market with regard to the various RETs: less mature technologies will possess a higher risk profile in terms of development and deployment, and this in turn can affect investor/developer decisions over which technologies to adopt. As stated in Chapter Four, liberalisation of the electricity sector has had profound effects on the context within which technological progress and diffusion occurs, with mature technologies chosen first in order to minimise risk and maximise deployment and investment returns (Foxon *et al*., 2005). In other words, some RETs have a cost advantage over other options. Although there is nothing intrinsically wrong with categorising renewable energy technologies in this way (they are after all typically more expensive than non-renewable technologies and the overall aim is to achieve cost-competitiveness), such an approach does not take into account non-economic attributes that can and do vary significantly between the various RETs. In conjunction with the issues regarding the potential impact of the internal and external

[124] This stage also includes technologies not examined here such as biomass pyrolysis, fuel cells and steam cells.

failures on deployment, Table 5.2 also examines key non-economic attributes including resource potential (see above), technical attributes related to operating renewable electricity supply technologies within the overall electricity system and environmental attributes (in terms of greenhouse gas/pollutant emissions and landscape disturbance and noise).

Looking at the technical attributes, one of the major benefits of conventional (fossil fuel-based) electricity technologies, in addition to reduced capital costs (construction) and increased technological maturity over renewable energy technologies, is that they can provide a stable, reliable source of electricity generation. This means that they are a non-intermittent source of power that does not require back-up generation plant to run when the resource is either not available or, more likely, when the available resource is reduced (for example, when wind speeds drop, rainfall is reduced or the sun is not shining). However, this does not mean that fossil fuel and nuclear power stations do not require back-up generation plant when they are offline, whether due to planned (for example, maintenance needs) and unplanned outages. The importance of this cannot be over emphasised, given that electricity cannot currently be stored at any meaningful scale at least economically.[125] In addition, fossil fuel generating stations are also flexible in the sense that they can be turned on or off, or the output increased or decreased to meet changes in demand profiles when required.[126] In contrast, renewable and low-carbon technologies possess a variety of often conflicting attributes.

An analysis of the data contained in Table 5.2 shows that, in general, renewable energy technologies can be divided into two gross overall groups with regard to the key non-economic attributes highlighted. On the one hand, there are those RETs which exhibit a high-degree of intermittency, are non-flexible in terms of operation and require back-up during the periods when the resource is unavailable (or availability is constrained by reduced resource or in the case of wind power, over available due to wind speeds above

---

[125] The main exception to this is pumped storage.

[126] There are differences in flexibility of operation within the fossil fuel (conventional) technology category.

the technical parameters). This category includes onshore wind, offshore wind, solar photovoltaic and marine RETs, and all of these RETs possess significant and infinite reserves of renewable energy, with the highest reserves for wind power in general and offshore wind in particular. Yet these RETs, in particular onshore and offshore wind are anticipated to contribute the overwhelming majority of RES-E deployment to 2020 and beyond. Onshore wind, currently one of the most economically competitive sources of renewable energy, is expected to play a major role in UK deployment at least to 2020, although the resource potential set out in the four reports analysed in Table 5.1 could be argued to over-estimate the resource, when constraints such as land-use and growing opposition to onshore wind power is taken into consideration. Also, offshore wind is expected to contribute significantly to renewable deployment to 2020 and beyond, with marine renewables to contribute significantly beyond 2020. However, one exception to this category, in terms of intermittency, is the marine renewables: although intermittent, they are more predictable in their intermittency due to the nature of the resource itself.

In contrast, hydro power, geothermal and biomass RETs are more similar to the majority of fossil fuel technologies in that they are non-intermittent sources of energy, exhibiting operational flexibility and as a result not potentially requiring the same level of back-up. This is significant as maximising the utilisation of these resources could reduce reliance on conventional fossil fuel generation as a source of back-up (or base-load) generation. The negative aspect of this category is that, with the exception of geothermal, the resource potential is constrained by the fact that reserve exploitation needs to be managed in order that the resource can replenish itself over an appropriate timescale without risk of depletion, and that there are significant sustainability, land-use and greenhouse gas emission risks associated with a number of biomass technologies and fuels. There is also limited resource potential for hydro power in comparison to the majority of RETs.

When the data is looked at in this way, it appears that those RETs with the largest infinite reserves are also the same technologies that exhibit those very attributes that create tension in the way they will function in the existing wider electricity system. On the other hand, those renewable technologies with constrained resource reserves (infinite-M) appear to be more adapted to the way the electricity system in the UK currently operates, and could play an important if not critical role in replacing the use of conventional generation. Such an analysis of the conflictive attributes of the various RETs reveals not only the options that exist but the complex trade-offs that would require resolution. Deploying more RETs in the first category could require more conventional back-up or the construction of expensive electricity network infrastructure, including upgrading and reinforcement of the UK system and the development of an offshore and international interconnected system between the UK and third countries. Deploying more second category RETs could increase problems of sustainability but decrease reliance on the solutions required for wind, solar and marine renewable energy technologies. In addition, when the distinction between terrestrial and marine (or non-terrestrial) renewables is made, offshore RETs do not currently exhibit the same level of resource constraints as onshore technologies. However, this will be dependent on experience learnt as deployment for these technologies increases, for example resource competition from other users, potential environmental constraints, grid connection and technology issues (see Part III of the thesis). All land-based renewable energy technologies face some type of constraint on resource usage and hence deployment (this will be examined further in Part III). When all the key attributes are taken into account, however, offshore wind is the only non-terrestrial technology that has the potential to deploy at the necessary scale, particularly in light of the 2020 target.

There are, however, a number of additional characteristics more or less unique to renewable electricity technologies portrayed in the last five columns of Table 5.2. The first three columns examine those characteristics that revolve primarily around the issue of scale. RETs are often small-scale (in terms of both installed capacity and generation output) and are geographically widespread in their pattern of dispersal. This can be seen from Figures 5.1 and 5.2 which graphically portray the significant dispersal (although sometimes overlapping) geographical range of the various renewable resources. This issue is compounded by the concentration of the best available resources in particular or specific geographical locations and the reality that developers will actively seek to locate their projects in these resource rich areas in order to maximise returns. In addition, renewable generating stations can be large-scale in terms of individual plant size. This is in contrast to conventional thermal and nuclear power plants which are compact units (small relative plant size), typically representing hundreds or thousands of MW of installed capacity with limited geographical dispersion. Importantly, the electricity transmission and distribution infrastructure was designed primarily to deliver large quantities of electricity from such generation technologies. As such, the electricity network was not meant to have a multitude of small-scale and often intermittent generating plant connected at different points all across the system.

This results in considerable variation in the above characteristics for RETs in comparison to both low carbon technologies (including nuclear and CCS) and fossil fuel technologies. At one end of the scale there are RETs that are currently deployed as very small-scale, highly dispersed units with typically low installed capacity and generation output profiles. Examples of such technologies can include onshore wind, hydro and certain biomass and waste plant (for example, sewage gas and anaerobic digestion). The technology that best exemplifies this characteristic is solar photovoltaics in particular and small-scale and microgeneration technologies in general.[127] These would usually exhibit small plant or unit size. However, some of the same RETs can also be scaled-up. For example, hydro and biomass plants can range up to hundreds of MW of installed capacity: Tilbury coal-fired power station was recently converted to a 750 MW biomass power plant in 2011.[128]

---

[127] Although this dissertation looks at large-scale RETs supported under the RO (with a typical deployment of > 5MW installed capacity), the recent deployment rate of solar photovoltaics has implications for UK RES-E deployment rates: solar PV installed capacity grew by +899 MW between 2010 and 2011. In 2011, then, solar PV accounted for the single largest growth in deployment in the UK (DECC, 2012a). As such, this technology will be examined further from Chapter Five onwards. All other small-scale or microgeneration technologies exhibited insignificant growth: solar PV accounted for over 90% of all FIT deployment and micro-wind accounted for only 20 MW (DECC, 2012b; Office of Gas and Electricity Markets [OFGEM], 2012).

[128] Due to the modular nature of most RETs, practically any such technology can be scaled up if the right conditions prevailed (e.g. financial, location, resource, etc). Typically the smallest-scale RET, solar PV can and has been scaled up in size: currently the largest solar PV plant in the world, the Perovo plant in Ukraine has an installed capacity of 100 MW (SolarPlaza, 2011).

This scaling-up is also exemplified by wind power. These technologies have the potential to deploy at sizes comparable or even larger than the biggest fossil fuel and nuclear plant. This is particularly the case for offshore wind where individual plant size (in MW installed capacity) is on average larger than that for onshore wind.[129] Such differences between these two RETs can only be amplified by the projects proposed in the Crown Estate's Round 3 offshore wind leasing programme. In contrast to Round 1 (ranging from 62 to 194 MW installed capacity) and Round 2 (65 to 1,200 MW), Round 3 projects range in size from 665 to 9,000 MW (Crown Estates, 2012; Renewables UK, 2012). In comparison, the largest onshore wind farm is Whitelee wind farm in Scotland at 322 MW (Scottish Power, 2011). The size of the individual plant is also typically considerably larger than fossil-fuel and nuclear power stations. Whitelee onshore wind farm covers over 50 square kilometres (km^2). In contrast, offshore wind farms can range up to 6,500 km^2, the equivalent size of Yorkshire (4coffshore, 2011). This is the largest example, however, and on average the proposed Round 3 offshore wind farms will be significantly smaller although still around a third to half that size in reality (Crown Estates, 2012). In contrast, coal, gas or nuclear power plant size is typically only a few square kilometres in size. As such, it can be argued that such renewable installations can be classified as 'industrial-scale' power stations, particularly in terms of their impact on the landscape and the wider electricity system.

The significance of the issue of scale, then, is that different RETs will have different implications with regard to a number of potential constraints, including notably planning, grid and public acceptance (this will be examined further in Part III of the thesis). The discussion has so far centred around two specific scales, small and large-scale renewable deployment, with the former scale supported under the FIT and the latter supported under the RO (although there is some overlap in RETs being able to accredit under either mechanism with an installed capacity of less than 5 MW due to the transition arrangements put in place when the FIT was implemented in April 2010). In

[129] An examination of the size distribution of onshore and offshore wind reveals that 70% of onshore wind farms and only 28% of offshore wind farms are smaller than 100 MW installed capacity, with the opposite for farms > 100 MW. The same pattern holds for hydro plant (< 100 MW: 89%, > 100 MW: 11%) (DECC, 2012a). This will be explored further in Part III of the dissertation.

addition to small-scale (defined as < 5 MW of installed capacity) and large-scale RETs (> 5 MW installed capacity), there is also the 'meso-scale' (>5 to 50 MW) (Watson *et al.*, 2010). The meso-scale has been argued to be more suitable for communities, co-operatives and smaller firms and organisations including local authorities and farmers (and smaller energy companies as opposed to multinationals and former utilities) that are better placed to exploit renewables at this sub-industrial scale. Such decentralised power generation is also argued to be more acceptable to the public, encourage behavioural change towards energy in general and renewables in particular on the grounds of increasing public participation, empowerment and self-sufficiency and therefore play an important role in RES-E deployment in the UK (Greenpeace, 2005; Nolden, 2011; Watson and Devine Wright, 2011). Importantly, the benefits of both small and meso-scale technologies could also apply to the delivery infrastructure and resilience of the overall energy system. Unlike small-scale deployment, which benefits from both the FIT and the RO (although some RETs might be excluded from this, see Chapter Six), the meso-scale falls within the remit of the RO which is primarily a mechanism for truly large-scale installations and of particular technology types (see also Chapter Six). Therefore, the potential constraints can also impact on the various RETs in a number of different ways, particularly the financial (subsidy) mechanism.

There is also the issue of '*landscape*'. A major concern that is consistently and repeatedly raised for different RETs at the local or national scale is that of the impact on the landscape (Nadaï and van der Horst, 2010). This is a very broad category containing numerous and often-linked and complex issues. An additional difficulty in the examination of these factors is that they are invariably subjective: for example, not all people dislike onshore wind turbines or are negatively impacted by the noise. Others believe that they ruin the landscape and damage the natural environment. Even at the smallest deployment scale, people can oppose or dislike the installation of a few square metres of solar photovoltaic panels on a residential roof (Devine-Wright, 2011).

Although these issues will be examined in more detail when evaluating the planning system and renewable electricity technologies (see chapter eight, section 8.2.2), the purpose of including 'landscape impact' in Table 5.2 is primarily to highlight the gross difference, perceived or otherwise, between renewable, low carbon and fossil fuel technologies. The key point here is that of scale, particularly in terms of the level of geographic dispersal and plant size (acreage under development). As mentioned previously, there are issues regarding even the smallest-scale RET installations, and this certainly applies to large-scale centralised power generating stations including low carbon and fossil fuel power stations. Such arguments typically focus on the local scale when non-GHG environmental factors are considered.[130] The last column of Table 5.2, then, shows that onshore and offshore wind power have the highest impact on the landscape in contrast to other RETs, low carbon and fossil fuel technologies. This is primarily due to the high level of geographic dispersal, highest resource areas and plant size of these two technologies. Marine RETs, including wave and tidal stream, are an exception to this. Both technologies also have the potential to deploy at large-scale and exhibit potential plant size comparable to wind, in particular offshore wind power. However, the limited real-time deployment history and experience means that it is difficult to currently establish the potential impact of these technologies on landscape disturbance (and other issues such as noise, radar, biodiversity, visual impact and cumulative impact).

[130] It goes without saying that fossil fuel plant have environmental impacts beyond the local scale, not just regarding the issue of GHG emissions and the impact of climate change which is intrinsically global in nature but also due to the impact of exploration, extraction, transport, processing and waste (the latter issues also apply to nuclear power and renewables to varying extent). This is also the case for certain biomass electricity generating technologies including growing the fuels and their sourcing and sustainability, transport and conversion.

References

4COffshore, 2011. Offshore wind Farms – Welcome to the Global Offshore Wind farms Database [online] Available from http://www.4coffshore.com/windfarms/

Arup, 2011. Review of the generation costs and deployment potential of renewable electricity technologies in the UK: Study report REP001 Final – Updated October 2011 for the Department of Energy and Climate Change [online] Available from http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renew_obs/1834-review-costs-potential-renewable-tech.pdf

Boyle. G. 2004. Renewable Energy: Power for a Sustainable Future – Second Edition (Ed). Oxford University Press: Oxford.

BusinessGreen, 2012. Hendry: UK's nuclear reactor fleet could be extended beyond 2025 [online] Available from http://www.businessgreen.com/bg/news/2154302/hendry-uks-nuclear-reactor-fleet-extended-2025?WT.rss_f=&WT.rss_a=Hendry:+UK's+nuclear+reactor+fleet+could+be+extended+beyond+2025&utm_source=twitterfeed&utm_medium=facebook

Committee on Climate Change [CCC], 2010. The Fourth Carbon Budget: Reducing emissions through the 2020s – 7 December 2010 [online] Available from http://www.theccc.org.uk/reports/fourth-carbon-budget

Committee on Climate Change, 2011a. Meeting Carbon Budgets – 3rd Progress Report to Parliament – June 2011 [online] Available from http://hmccc.s3.amazonaws.com/Progress%202011/CCC_Progress%20Report%202011%20Single%20Page%20no%20buttons_1.pdf

Committee on Climate Change [CCC], 2011b. CCC response to Huhne's 4th Carbon Budget statement – 17 May 2011 [online] Available from http://www.theccc.org.uk/news/latest-news/949-ccc-response-to-huhnes-4th-carbon-budget-statement-17-may-2011

Crown Estate, 2012. Offshore wind energy [online] Available from http://www.thecrownestate.co.uk/energy/offshore-wind-energy/

Daily Telegraph, 2012. Centrica shareholders revolt against executive pay – 11 May 2012 [online] Available from http://www.telegraph.co.uk/finance/newsbysector/energy/9261237/Centrica-shareholders-revolt-against-executive-pay.html

Department of Energy and Climate Change (DECC), 2009a. UK low Carbon Transition Plan: National strategy for climate and energy [online] Available from http://www.decc.gov.uk/publications/basket.aspx?FilePath=White+Papers%2fUK+Low+Carbon+Transition+Plan+WP09%2f1_20090724153238_e_%40%40_lowcarbontransitionplan.pdf&filetype=4#basket

Department of Energy and Climate Change (DECC), 2009b. UK Renewable Energy Strategy [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/renewable%20energy%20strategy/1_20090717120647_e_@@_theukrenewableenergystrategy2009.pdf

Department of Energy and Climate Change [DECC], 2009c. Government Response to the 2009 Consultation on the Renewables Obligation [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20091214132326_e_@@_GovernmentResponse2009ConsultationontheRenewablesObligation.pdf

Department of Energy and Climate Change (DECC), 2010a. 2050 Pathways Analysis – July 2010 [online] Available from http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/2050/216-2050-pathways-analysis-report.pdf

Department of Energy and Climate Change (DECC), 2010b. Severn Tidal Power: feasibility Study Conclusions and Summary report – October 2010 [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/severn-tp/621-severn-tidal-power-feasibility-study-conclusions-a.pdf

Department of Energy and Climate Change [DECC], 2011a. UK Proposes Fourth Carbon Budget – Press Release: 11/040 – 17 May 2011 – Emissions to be cut by 50% by 2025 [online] Available from http://www.decc.gov.uk/en/content/cms/news/pn11_41/pn11_41.aspx

Department of Energy and Climate Change [DECC], 2011b. Implementing the Climate Change Act 2008: The Government's proposal for setting the fourth carbon budget – Policy Statement – May 2011 [online] Available from http://www.decc.gov.uk/publications/basket.aspx?filetype=4&filepath=What+we+do%2fA+low+carbon+UK%2fCarbon+budgets%2f1683-4th-carbon-budget-policy-statement.pdf&minwidth=true#basket

Department of Energy and Climate Change (DECC), 2011c. National policy Statements for Energy Infrastructure – Overarching National Policy Statement for Energy (EN-1) – Updated July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/nps_en_infra/nps_en_infra.aspx

Department of Energy and Climate Change (DECC), 2011d. Renewable Heat Incentive (RHI) Scheme [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

Department of Energy and Climate Change [DECC], 2011e. The Carbon Plan: Delivering our low carbon future – December 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx

Department of Energy and Climate Change [DECC], 2011f. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change (DECC), 2011g. Updated energy and emissions projections – October 2011: Central Scenario [online] Available from http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3120-annex-e-total-electricity-gen-by-source.xls

Department of Energy and Climate Change [DECC], 2011h. UK Offshore Energy Strategic Environmental Assessment – OESEA2 Environmental Report: Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil & Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure - February 2011 [online] Available from http://www.offshore-sea.org.uk/consultations/Offshore_Energy_SEA_2/OESEA2_ER_with_NTS_Part1.pdf

Department of Energy and Climate Change (DECC), 2012a. Digest of United Kingdom Energy Statistics 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/5949-dukes-2012-exc-cover.pdf

Department of Energy and Climate Change (DECC), 2012b. Energy Trends – September 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/6479-energy-trends-sep-2012.pdf

Department for Environment, Food and Rural Affairs [DEFRA], 2008. Addressing the land use issues for non-food crops, in response to increasing fuel and energy generation opportunities [online] Available from http://www.biomassenergycentre.org.uk/pls/portal/docs/PAGE/RESOURCES/REF_LIB_RES/PUBLICATIONS/RESOURCE%20AVAILABILITY/NNFCC08-004ADASLANDUSEREPORT.PDF

Department for Environment Food and Rural Affairs, 2012. Large Combustion Plant Directive [online] Available from http://www.defra.gov.uk/industrial-emissions/eu-international/lcpd/

Devine-Wright, P. 2011. Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

EDF, 2012. Talk Power 2012: Powering on: investing for growth and a sustainable future – Vincent de Rivaz CBE – 25 April 2012 [online] Available from http://www.edfenergy.com/media-centre/press-news/Speech_by_Vincent_de_Rivaz_Talk_Power_250412.pdf

Energy and Climate Change Committee, 2011a. Shale Gas – Fifth Report of Session 2010-12: Volume I: Report, together with formal minutes, oral and written evidence – 10 May 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/795/795.pdf

Energy and Climate Change Committee, 2011b. Shale Gas – Fifth Report of Session 2010-12: Volume II: Additional written evidence – 23 May 2011 {online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/795/795vw.pdf

Energy Systems Research Unit [ESRU], 2011. Wind Speed Map of the UK [online] Available from http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/wind/content/ukwindspeedmap.html

Eur-Lex, 2001. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0077:EN:NOT

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Foxon, T.J., Gross, R., Chase, A., Howes, J., Arnall, A., Anderson, D., 2005. UK innovation systems for new and renewable energy technologies: drivers, barriers and systems failures. Energy Policy 33, 2123–2137

Freight Transport Association Limited, 2011. UK climate change policy and legislation [online] Available from http://www.fta.co.uk/export/sites/fta/_galleries/downloads/climate_change/climate_change_policy_0210.pdf

Greenpeace, 2005. Decentralising Power: An Energy Revolution for the 21st Century [online] Available from http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7154.pdf

Grubb, M. and Vigotti, R. 1997. Renewable Energy Strategies for Europe – Volume II: Electricity Systems and Primary Electricity Sources. Earthscan Publications Ltd: London.

Guardian, 2011a. Nuclear giants RWE and E.ON drop plans to build new UK reactors: German nuclear companies pull out of Horizon project for two new nuclear plants, with France's EDF most likely to pick up contract – 29 March 2012 [online] Available from http://www.guardian.co.uk/environment/2012/mar/29/nuclear-reactors-rwe-eon-energy

Guardian, 2011b. Hinkley nuclear power station delay deals blow to government hopes: Earthwork preparation of Hinkley site put back as election of Francois Holland as French president hits confidence – 14 May 2012 [online] Available from http://www.guardian.co.uk/environment/2012/may/14/hinkley-nuclear-power-station-delay

Guardian, 2011c. Scottish government signals end to nuclear power opposition: Energy minister says SNP is 'perfectly open' to extending the life of existing nuclear power stations – Friday 1 July 2011 [online] Available from http://www.guardian.co.uk/environment/2011/jul/01/scottish-government-nuclear-power-snp/print

Helm, D. 2003. Energy, the State, and the Market – British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford.

Jamasb, T., Nuttall, W.J., Pollitt, M.G. and Maratou, A., 2008. Technologies for a low-carbon electricity system: an assessment of the UK's issues and options, in: Grubb, M., Jamasb, T. and Pollitt, M.G. (Eds), Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy. Cambridge University Press: Cambridge.

Laing, T. and Grubb, M. 2010. Low Carbon Electricity Investment: The Limitations of Traditional Approaches and a Radical Alternative – EPRG Working Paper 1032 [online] Available from http://www.eprg.group.cam.ac.uk/wp-content/uploads/2010/09/Binder12.pdf

Nadaï and van der Horst, 2009. Editorial: Wind power planning, landscapes and publics. Land Use Policy 27(2010): 181-184.

National Archives, 2008. Climate Change Act 2008 (Chapter 7) [online] Available from http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

National Archives, 2009. Climate Change (Scotland) Act 2009 (2009 asp 12) [online] Available from http://www.legislation.gov.uk/asp/2009/12/pdfs/asp_20090012_en.pdf

National Audit Office, 2012. Carbon capture and storage: lessons from the competition for the first UK demonstration [online] Available from http://www.nao.org.uk/publications/1012/carbon_capture_and_storage.aspx

Nolden, C. Regulating energy security through the diffusion of innovation – A community perspective [online] Available from http://www.exeter.ac.uk/energysecurity/documents/ese_resources_May2012/Colin_Nolden.pdf

Nuclear Industry Association, 2012. UK nuclear power stations [online] Available from http://www.niauk.org/uk-nuclear-statistics.html

Office of Gas and Electricity Markets [OFGEM], 2012. Feed-in Tariff Update: Issue 7 – March 2012 [online[Available from http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/Feed-in%20Tariff%20(FIT)%20Update%20Newsletter%20Issue%207.pdf

Offshore Valuation Group [OVG], 2010. The Offshore Valuation: A valuation of the UK's offshore renewable energy resource [online] Available from http://www.offshorevaluation.org/

Platchkov, L., Pollitt, M. and Shaorshadze, I. The implication of recent UK energy policy for the consumer: A report for the Consumer's Association – ESRC Electricity Policy Research Group – University of Cambridge May 2011 [online] Available from http://www.eprg.group.cam.ac.uk/wp-content/uploads/2011/05/ReportforCAFinal100511EPRG.pdf

Power, 2012. Novel Floating Offshore Wind Turbine Deployed in the Atlantic – February 1 2012 [online] Available from http://www.powermag.com/renewables/wind/4319.html

Renewable Energy Policy Network for the 21st Century [REN21], 2011. Renewables global Status Report [online] Available from http://www.ren21.net/

Renewables UK, 2012. Offshore wind [online] Available from http://www.bwea.com/offshore/index.html

Scotland and Northern Ireland Forum for Environmental Research [SNIFFER], 2010. Impacts of Biomass and Bioenergy Crops on Landscape, Land Use and the Wider Environment in Northern Ireland and Scotland – March 2010 [online] Available from http://www.sniffer.org.uk/Webcontrol/Secure/ClientSpecific/ResourceManagement/UploadedFiles/ER05_Final_Project_Report_v3.1.pdf

Scottish Government, 2011a. Climate Change (Scotland) Act 2009 [online] Available from http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/climatechangeact

Scottish Government, 2011b. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011c. Getting the best from our land: A land use strategy for Scotland [online] Available from http://www.scotland.gov.uk/Publications/2011/12/19161736/9

Scottish Power, 2011. Whitelee Windfarm [online] Available from http://www.whiteleewindfarm.com/outdoor_pursuits/future_developments

SolarPlaza, 2011. Top 10 World's Largest Solar PV Power Plants [online] Available from http://www.solarplaza.com/top10-largest-pv-power-plants/#perovo

Šúri, M., Cebecauei, T., Huid, T. and Dunlop, D, 2001. Solar Map of the UK [online] Available from http://re.jrc.ec.europa.eu/pvgis/cmaps/eu_opt/pvgis_solar_optimum_GB.png

The Royal Society and The Royal Academy of Engineering, 2012. Shale gas extraction in the UK: a review of hydraulic fracturing – June 2012 [online] Available from http://royalsociety.org/policy/projects/shale-gas-extraction/report/

Toke, D. 2011. David Toke's green energy blog [online] Available from http://realfeed-intariffs.blogspot.com/search?updated-min=2011-01-01T00:00:00-08:00&updated-max=2012-01-01T00:00:00-08:00&max-results=22

Watson, J. and Devine Wright, P. 2011. Centralisation, decentralisation and the scales between: What role might they play in the UK energy system: Revised chapter for Supergen book edited by Michael Pollitt and Tooraj Jamasb: "Electricity and Heat Demand in a Low-Carbon World" [online] Available from www.supergen-networks.org.uk/filebyid/586/file.doc

Watson, J., Scrase, I. and Stapleton, L. 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables Target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Woodman, B. 2008. Connecting the future: the UK's renewable energy strategy – A report by Dr Bridget Woodman of the University of Exeter: Commissioned by Greenpeace – September 2008 [online] Available from http://www.greenpeace.org.uk/files/pdfs/climate/connectingthefuture.pdf

Chapter Six

Chapter Six

Trends in Renewable Electricity Installed Capacity and Generation Output in the United Kingdom

6.1 Introduction

The first two chapters of Part II of the thesis set out the context regarding large-scale RETs. This chapter establishes the baseline contribution of renewable electricity in the UK and analyses the trends in RET deployment in terms of installed capacity and generation output. This is important in order to evaluate constraints to RET deployment. Section 6.2 looks at the historical trends and current contribution of the individual renewable electricity technologies in the UK, including at the sub-national level with particular emphasise on Scotland out of the devolved national administrations. Linking with the literature review (chapter three) and the contextual data provided in chapter's four and five, this analysis will be used to show which technologies dominate and those that have not deployed significantly despite over twenty years of government support. It can also reveal changes in deployment trends. Section 6.3 determines the actual level of renewable electricity deployment required to meet the sectoral target for electricity for 2020. This will indicate the required level of deployment required to meet the 2020 sectoral target for the various technologies.

There are a number of sources providing data on energy statistics for the UK as a whole and at the sub-national level for England and the three national devolved administrations: Scotland, Wales and Northern Ireland. This thesis utilises a number of sources in order to construct an up-to-date, detailed and comparable baseline assessment of the contribution of RES-E in the four countries that constitute the UK. The key official government databases containing RET capacity and generation output are published by the Department of Energy and Climate Change (DECC). These include: the Digest of United Kingdom Energy Statistics (DUKES), Energy Trends and the Renewable Energy STATisticS database (RESTATS). In addition, there are a number of databases developed by other bodies including the renewable trade organisations (Renewable UK, Scottish Renewables) and non-governmental organisations (WWF, Greenpeace, Friends of the Earth). Although there are some discrepancies in the way in which such data is collected or presented, all relevant data has been cross-checked to ensure accuracy. Further, the data cut-off point is the end of December 2011 unless otherwise stated.

6.2 Historical and current trends in UK renewable electricity deployment

Table 6.1 (page 174) provides a detailed breakdown of the installed capacity (MW) and generation output (GWh) for the main renewable electricity technologies from 2002 to 2011 at the UK level. These include wind power (onshore wind, offshore wind), shoreline wave and tidal power, hydro power (large and small-scale) and biomass electricity (landfill gas, sewage gas, co-firing, other biomass). The data is also aggregated into the three major RET '*families*'. Pumped storage is excluded as it is not categorised as a renewable energy technology.[131] In addition, solar photovoltaic is included despite all deployment so far being supported under the small-scale FIT mechanism.

Table 6.1 shows the gross positive trend in UK renewable electricity deployment installed capacity and generation output between 2002 and 2011. Looking at installed capacity, Part A of Table 5.1 reveals that total installed capacity has increased four-fold during the period analysed, from 3,147 MW in 2002 to 12,648 MW in 2011. At the RET family level, wind power has driven growth in deployment. Accounting for around 17% of total RES-E installed capacity in 2002 (of which onshore wind accounted for 99.7 per cent of the total), wind power installed capacity now comprises just over half of all renewable electricity deployment in 2011 (+6,488 MW), more installed capacity than for all other renewable technologies combined (51 per cent). Total wind power capacity increased by around +1,217 per cent between 2002 and 2011. Historically, hydro and

[131] Another distinction when discussing renewable energy in the United Kingdom is whether or not a renewable energy (electricity) technology is RO-eligible or non-RO eligible: when discussing hydro power in the United Kingdom, the distinction between small scale and large scale hydro is that the former is RO-eligible (if under 20 MW installed capacity) whereas the latter, by definition being greater than the 20 MW cut-off limit, is classified as a non-RO eligible technology, although it is a source of renewable energy and therefore counts towards any renewable targets.

Table 6.1 Capacity of, and electricity generated from renewable sources in the UK from 2002 to 2011 (Adapted from DECC, 2006; DECC, 2009a, b; DECC 2011a,b,c,d,e; DECC, 2012a)

A	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Installed capacity (MW)										
Wind										
(1) Onshore	530	678	809	1,351	1,650	2,083	2,820	3,483	4,037	4,650
(2) Offshore	3.8	63	123	213	303	393	586	941	1,341	1,838
Shoreline Wave/tidal	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.5	3	3
Solar photovoltaic	*	*	*	*	*	*	*	*	77	976
Hydro										
(1) Small scale	194	118	135	157	153	166	173	186	188	1,676
(2) Large scale [1]	1,396	1,366	1,367	1,355	1,361	1,358	1,456	1,458	1,453	
Biomass										
(1) Landfill gas	472	619	722	817	856	900	908	984	1,025	1,067
(2) Sewage gas	96	100	119	127	143	150	147	156	186	198
(3) Co-firing	-	92	146	308	310	247	226	254	266	338
(4) Other biomass [2]	455	482	483	507	547	630	688	789	882	1,902
Total hydro	**1,590**	**1,484**	**1,502**	**1,512**	**1,514**	**1,524**	**1,629**	**1,644**	**1,641**	**1,649**
Total wind	**533**	**741**	**932**	**1,564**	**1,953**	**2,476**	**3,406**	**4,424**	**5,378**	**6,488**
Total biomass	**1,023**	**1,293**	**1,470**	**1,759**	**1,856**	**1,927**	**1,969**	**2,183**	**2,359**	**3,505**
Total (MW)	**3,147**	**3,518**	**3,904**	**4,835**	**5,327**	**5,927**	**7,004**	**8,251**	**9,458**	**12,648**

B	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Generation output (GWh)										
Wind										
(1) Onshore	1,251	1,276	1,736	2,505	3,574	4,491	5,792	7,564	7,137	10,372
(2) Offshore [3]	5	10	199	403	651	783	1,305	1,740	3,046	5,126
Solar photovoltaic	*	*	*	*	*	18	23	27	77	252
Hydro										
(1) Small scale	204	143	283	467	478	534	568	598	511	5,686
(2) Large scale [1]	4,584	3,085	4,647	4,494	4,115	4,554	4,600	4,664	3,092	
Biomass										
(1) Landfill gas	2,679	3,276	4,004	4,290	4,424	4,677	4,757	4,952	5,037	4,979
(2) Sewage gas	368	343	379	400	445	449	532	598	702	755
(3) Co-firing	286	602	1,022	2,533	2,529	1,956	1,613	1,806	2,508	2,964
(4) Other biomass [4/5]	1,747	1,902	1,898	1,819	1,880	2,141	2,381	3,240	3,670	4,275
Total hydro	**4,788**	**3,228**	**4,930**	**4,961**	**4,592**	**5,088**	**5,168**	**5,262**	**3,603**	**5,686**
Total wind	**1,256**	**1,286**	**1,935**	**2,545**	**4,225**	**5,274**	**7,097**	**9,304**	**10,183**	**15,498**
Total biomass	**5,080**	**6,123**	**7,303**	**9,042**	**8,966**	**9223**	**9,283**	**10,596**	**11,917**	**12,973**
Total (GWh)	**11,124**	**10,637**	**14,168**	**16,548**	**17,784**	**19,585**	**21,548**	**25,162**	**25,703**	**34,157**

Note: [1] Excludes pumped storage. [2] Includes municipal solid waste combustion, animal biomass (including the use of farm waste digestion, anaerobic digestion, poultry litter and meat and bone) and plant biomass (includes the use of waste tyres, straw combustion, short rotation coppice and hospital waste). [3] Includes electricity from shoreline wave and tidal (less than 2 GWh) excluding the EMEC test facility. [4] The biodegradable part only is accounted for in municipal solid waste combustion (in the other biomass category. [5] Includes use of energy crops for plant biomass within other biomass category.

biomass originally dominated RET deployment. Since 2002, however, hydro power has evidenced virtually no growth in deployment, falling from 51 to just 13 per cent of total installed capacity in 2011. In contrast, biomass capacity has continued to increase, albeit at a significantly lower rate than wind power (+342 per cent, or 28 per cent of total installed capacity in 2011).

Total generation output of renewable electricity also increased, from 11,124 GWh in 2002 to 34,157 GWh in 2011 (Part B). Wind power has exhibited the greatest growth, from 11 per cent of total output to 45 per cent (+14,242 GWh). This is a twelve-fold increase in nine years; in contrast, although biomass grew two and half-fold in the same period (+7,893 GWh), the share of total generation output fell from 46 to 28 per cent due to increases in total wind power output. However, despite wind power having twice as much capacity installed as biomass, the latter RET family has a significantly higher generation output; indeed, wind power only surpassed biomass in 2011. This serves to highlight the differences between the various technology options (this is emphasised further below; see also chapter five). As expected from installed capacity trends, the output from hydro has declined from 42 per cent to 17 per cent in 2011. Despite the gross positive trend in total RES-E installed capacity and generation output between 2002 and 2011, Table 6.1 reveals a number of discrepancies, particularly for the years 2003 and 2010, where output fell and virtually flat-lined despite continuous annual increases in installed capacity, respectively.

In 2003 total generation output dropped for the first and so far only time at the UK level from 11,124 GWh in 2002 to 10,637 GWh whilst total installed capacity increased by +372 MW over the same period. Output reduced by 500 GWh due primarily to reduce rainfall affecting hydro power output. In the same year, onshore wind power output increased by just 3 per cent from 2002, despite capacity increasing by approximately 30 per cent due to reduced wind speeds. A similar event also occurred between 2009 and 2010. Although installed capacity increased by +1,207 MW generation output only increased by +541 GWh during 2009-10. However, the increase in output partially obscures the data: both hydro (-1,659 GWh) and onshore wind (-519 GWh) generation dropped significantly. This was the largest recorded reduction in hydro generation and the first example of a reduction in onshore wind generation evidenced in the period examined here. In actual fact, the combined increase in generation of those RETs displaying positive growth amounted to +2,627 GWh[132], but the decrease in hydro and onshore wind combined (-2,086 GWh) resulted in the stagnating rate of overall output.

The implications of this are significant, particularly if wind deployment increasingly commands a dominant position in the UK's renewable electricity (and energy) mix: because hydro and wind power are primarily dependent on rainfall and wind speed, the correlation between increasing installed capacity and generation output can be weakened or broken depending on the weather.[133] Critically, at the UK level, this resulted in electricity generated from RES-E only increasing from 6.7 to 6.8 per cent and was a key reason explaining why the UK missed the EU-set 2010 sectoral target.

Whilst the data can reveal declines in renewable generation between years, it can also highlight increases in generation. This can be seen for the years 2003-04 (+3,531 GWh), 2008-09 (+3,614 GWh) and particularly for 2010-11 (+8,454 GWh). There are a number of reasons that can explain this. As previously stated in this chapter, this step-increase is due in part to the high proportion of hydro generation and higher rainfall increasing hydro generation for the latter years. The strong overall positive growth in wind power has also played a role in the step-increases in generation: deployment has continued even in the years with reduced wind, such as between 2009 and 2010. Therefore, in the following year a '*rebound*' effect is to be expected as average wind speeds and rainfall pick up, there is more installed capacity to generate. This is the flip-side of the years evidencing declines in generation output.

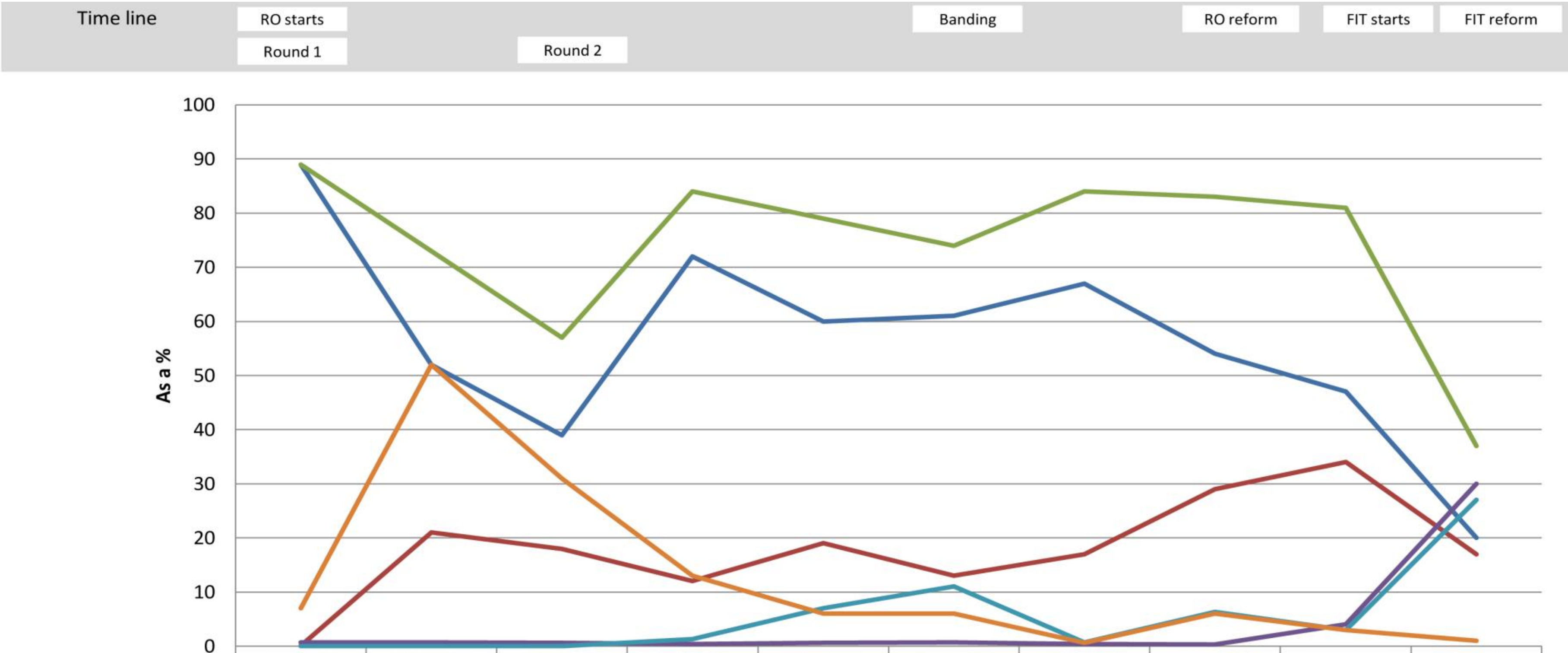
---

[132] In contrast, offshore wind increased by +1,306 GWh followed by co-firing (+702 GWh). Indeed, all biomass RETs showed positive growth. Overall, total biomass generated 46 per cent of UK total output in 2010, with total wind comprising 40 per cent. Unlike 2011, however, solar PV and plant biomass showed no real growth in the period 2009-10 (see below).

[133] This will also have particular implications for Scotland: RES-E installed capacity and generation output are overwhelmingly dominated by wind and hydro power (see below).

Although total overall installed capacity has increased, when separate technologies are examined a number of observations can be made from Part A and B of Table 6.1. Onshore wind is the major RET contributor in 2011 in terms of both installed capacity and generation output (+4,650 MW, or 37 per cent of total and 10,372 GWh, or 33 per cent of total RES-E output). This was an increase of almost 900 per cent (+4,120 MW) between 2002 and 2011. However, offshore wind increased by almost 50,000 per cent (+1,834 MW) during the same period, to +1,838 MW (15 per cent of total installed capacity), reflecting a negligible level of deployment in 2002. In general, both onshore wind and offshore wind have shown significant year on year growth in installed capacity in comparison to the other RETs. Regarding the individual biomass RETs, landfill gas increased by +226 per cent (+595 MW, or 8 per cent of total installed capacity), sewage gas has increased by +206 per cent (+102 MW, or 2 per cent of total installed capacity) and co-firing has increased by +267 per cent (+246 MW, or 3 per cent of total installed capacity). However, none of these biomass RETs have shown significant deployment capacity growth since the early to mid-2000s. This is also the case for shoreline wave tidal power and large-scale and small-scale hydro power.

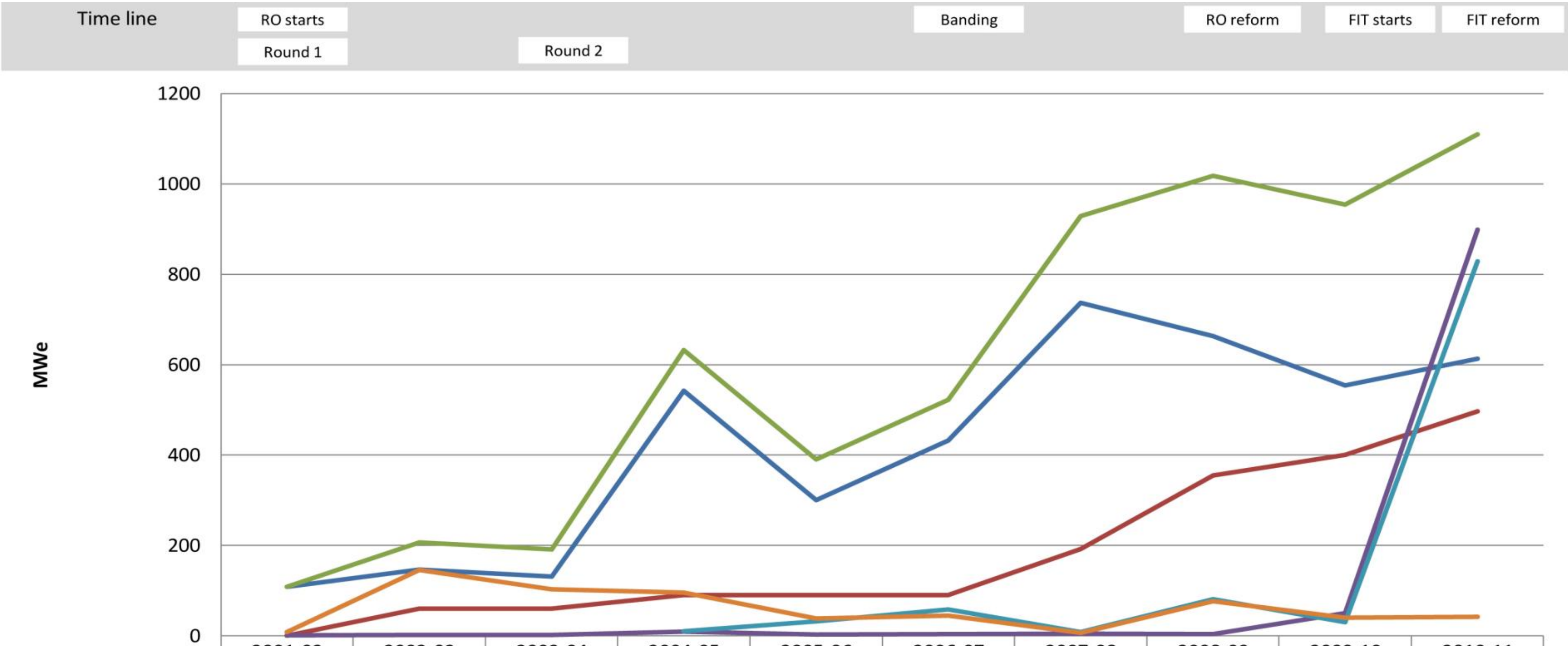
Importantly, the period 2010-11 showed the highest annual increase in installed capacity: +3,187 MW, almost three times the previous annual average growth of all RETs (see Table 6.1). At the same time, the dominant trends in deployment appear to change significantly (DECC, 2012a, b). Figures 6.1 and 6.2 (pages 178-179) graphically illustrate the abrupt and significant change by showing the relative annual growth of key RETs as a percentage of total RET growth (Figure 6.1) and absolute growth in installed capacity in MW (Figure 6.2). Over the period 2001-2010, in both relative and absolute terms, wind power dominated annual installed capacity growth, accounting for around 80 percent of annual new RES-E capacity growth on average. This is consistent with the anticipation that wind power, both onshore and offshore, will contribute the vast majority to the UK RES-E sectoral target (DECC, 2011f). However, in 2010-11, the share of total wind dropped from 81 percent in the previous year to just 37 percent, the first time that wind power has experienced such a drop in annual growth in installed capacity. Although the share of onshore wind to annual installed capacity had been



	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Onshore wind	89	52	39	72	60	61	67	54	47	20
Offshore wind	0.1	21	18	12	19	13	17	29	34	17
All wind	89	73	57	84	79	74	84	83	81	37
Solar PV	0.7	0.7	0.6	0.4	0.6	0.7	0.4	0.3	4	30
Plant biomass	0	0	0	1.3	7	11	0.7	6.3	3	27
Landfill gas	7	52	31	13	6	6	0.6	6	3	1

Figure 6.1 Annual growth of key individual technologies as a percentage of total renewable energy technology growth (2001-11)

Note: In the time line banding refers to the fact that grandfathering was introduced for projects which became operational or achieved planning consent after the publication of the RO reform proposals in July 2006 for eligible generating capacity to either retain 1 ROC/MWh (for those RETs to be bended down) and to move to the higher ROC/MWh category (for those RETs being banded up). Round 1 and 2 refer to Crown Estates first two offshore wind rounds (Crown Estates, 2011). FIT refers to the small-scale Feed-in Tariff mechanism implemented on 1 April 2010.



	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Onshore wind	108	147	131	542	300	432	737	663	554	613
Offshore wind	0	60	60	90	90	90	192	355	400	497
All wind	108	207	191	632	390	522	929	1018	954	1110
Solar PV	1	2	2	9	3	4	5	4	50	899
Plant biomass				10	32	58	8	81	30	829
Landfill gas	8	146	103	96	38	45	7	77	40	42

Figure 6.2 Annual installed capapcity growth in Mwe for key individual renewable energy technologies (2001-11)

Note: In the time line banding refers to the fact that grandfathering was introduced for projects which became operational or achieved planning consent after the publication of the RO reform proposals in July 2006 for eligible generating capacity to either retain 1 ROC/MWh (for those RETs to be bended down) and to move to the higher ROC/MWh category (for those RETs being banded up). Round 1 and 2 refer to Crown Estates first two offshore wind rounds (Crown Estates, 2011). FIT refers to the small-scale Feed-in Tariff mechanism implemented on 1 April 2010.

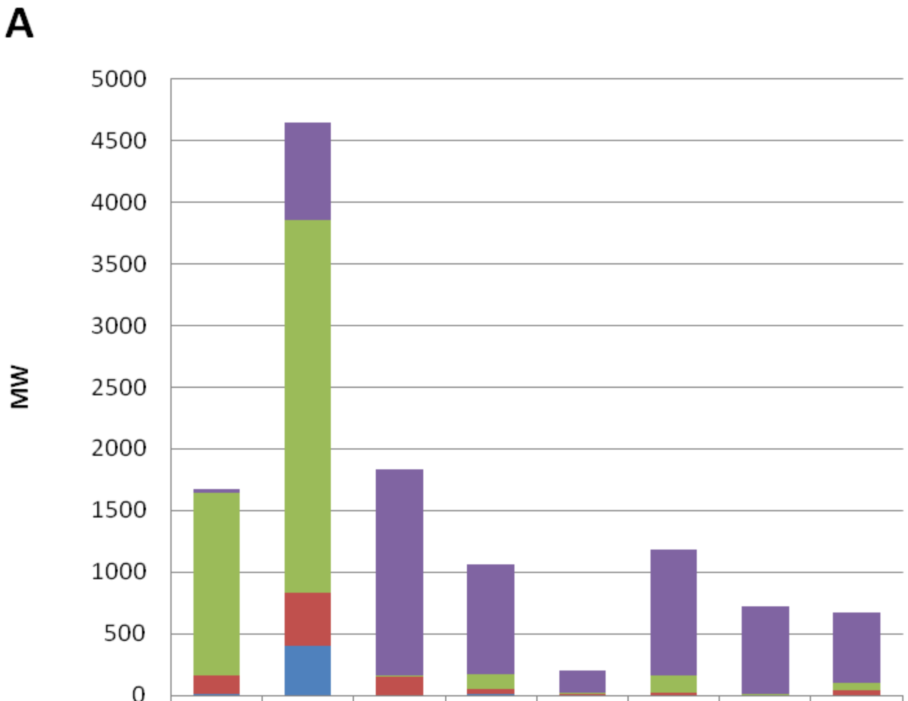
dropping in recent years due to a corresponding growth in the share of offshore wind, the primary reason is due to highly significant deployment growth in two RETs that had previously displayed very little growth overall: solar photovoltaic increased from 77 to 976 MW (+899 MW) and plant biomass (the key RET included in the '*other biomass*' category) from 330 to 1,159 MW (+829 MW), accounting for 30 and 27 percent of total installed capacity growth in the same period, respectively.[134] In comparison, onshore and offshore wind grew by +614 (20 percent) and +497 MW (17 percent), respectively.[135] However, whether or not this trend will continue will depend on a number of factors including changes in subsidy level. This will be looked at further in Part III of the thesis.

When the data for 2011 is broken down to provide a snap-shot of both installed capacity (Part A) and generation output (Part B) at the sub-national level, its is clear that England and Scotland dominate overall renewable electricity deployment and output in 2011 (Figure 6.3, page 181). Part A reveals that 65 per cent (+3,017 MW) of the UK's onshore wind installed capacity and 89 per cent (+1,459 MW) of total hydro is found in Scotland. England contains 91 per cent (+1,678 MW) of the installed capacity for offshore wind and 89 per cent (+2,809 MW) of total biomass. In contrast to a significant amount of onshore wind capacity, by 2010 Scotland had managed to deploy only +10 MW of offshore wind[136], and just 10% of the UK's biomass capacity (+266 MW). At the country level, England and Scotland dominate RES-E generation in the UK, with 48 per cent and 39 per cent, respectively. In contrast, both Wales (8 per cent, or +850 MW) and Northern Ireland (4 per cent, or +427 MW) combined only contain

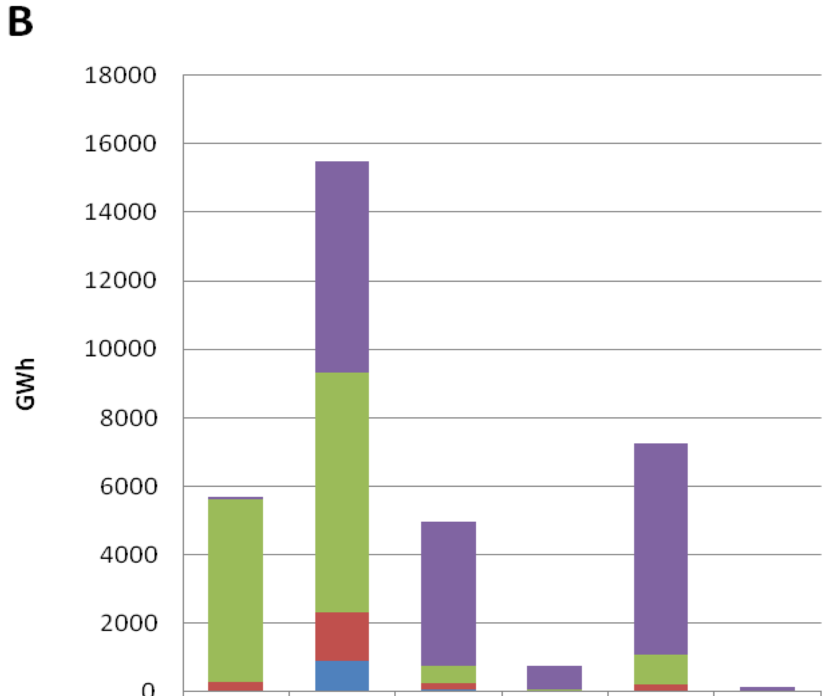
[134] The growth in plant biomass, and therefore 'other biomass' is due to Tilbury coal-fired power station (829 MW) being fully converted to biomass at the end of 2010. However, Tilbury biomass plant was closed on the 27 February 2012 due to a fire; plant closure for the majority of the year is reflected in the lower generation output for other biomass shown for the year 2011 in Table 5.1 (RWE npower, 2012).

[135] It should be pointed that Figures 5.1 and 5.2 do not analyse all RETs. However, the relevant data for the remaining RETs is taken into account in the statistics. The reason for the exclusion graphically was primarily for purposes of clarity and the fact that they accounted for around 10% or less of total deployment across the period.

[136] However, some renewable databases (e.g. RESTATS) allocate the Robin Rigg offshore wind farm (180 MW) as a Scottish generation plant. The method of allocation for offshore renewables used here is where the cabling comes ashore, in this case, at Seaton in Cumbria, England (4COffshore, 2011).



	Hydro	Onshore wind	Offshore wind	Landfill gas	Sewage gas	Plant biomass	Other biofuels [1]	Solar PV [2]
England	28.4	799	1678	898	177	1021	713	573
Scotland	1489	3017	10	113	8	133	12	60
Wales	150	432	150	45	12	20	1	40
Northern Ireland	8	402		11	0	5	0	1



	Hydro	Total wind [3]	Landfill gas	Sewage gas	Other biofuels [4]	Solar PV [5]
England	88	6162	4209	684	6150	129
Scotland	5332	6984	507	35	863	8
Wales	268	1439	205	35	203	9
Northern Ireland	19	893	59	1	22	0.4

Figure 6.3 Sub-national renewable electricity installed capacity (A) and generation output (B) in 2011 (Adapted from DECC, 2011a, b, c; DECC, 2012a, b, c). *Note*: All data as of 31 December 2011. Offshore wind is allocated to the country where the cabling comes ashore (same method for determining installed capacity location). [1] Other biofuels includes municipal solid waste combustion, animal biomass (excluding anaerobic digestion) and anaerobic digestion. Co-firing data cannot be shown at the sub-national level and therefore is not included in the other biofuels category. [2] Solar PV installed capacity data does not includes 314 MWe at other sites not recorded at the sub-national level. [3] Onshore and offshore wind generation output data is not separated at the sub-national level. [4] Other biofuels generation output includes co-firing and plant biomass data. [5] Solar PV generation output data does not include another 106 GWh generated at other sites not recorded at the sub-national level.

around 12 per cent of the total installed capacity of renewable electricity technologies in the UK. As with Scotland, both nations are dominated by wind. In contrast, England is the only country at the sub-national level not dominated by wind power, despite possessing the vast majority of UK-wide offshore wind installed capacity. Of interest, Wales has +150 MW of offshore wind, the second highest in terms of installed capacity by country (the same is also true for hydro power in Wales, at +149 MW). The trends revealed in Part B are similar to those for installed capacity. With a combined total of 91 per cent, England and Scotland dominate RES-E generation output, with 51 per cent and 40 per cent, respectively. When RETs are examined at the sub-national level, England dominates biomass generation (85 per cent of the UK total), Scotland dominates hydro (94 per cent) whilst both countries generate 85 per cent of all UK wind output: 40 per cent for England (due primarily to offshore wind) and 45 per cent (due overwhelmingly to onshore wind).

Table 6.2 (page 183) shows the installed capacity (Part A) and generation output (Part B) of renewable electricity technologies in Scotland for the years 2002 to 2011. As with the UK, Scotland generally follows the same trends (see Table 6.1): in 2011, onshore wind dominates both installed capacity and generation output, accounting for 63 and 51 per cent, respectively. This trend has continued for the period examined here. However, Scotland bucked the 2011 UK overall '*trend*' of low wind power deployment in both relative and absolute terms due to insignificant deployment of plant biomass (and biomass overall) and solar photovoltaic. Although hydro power is declining in relative terms, it is still significant in absolute terms, accounting for roughly a third of installed capacity and generation output in 2011. When the average amount of new annual installed capacity is examined at the technology level for the period 2002-11, approximately 86 percent of new installed capacity in Scotland is onshore wind; the figure is significantly higher for some years. In contrast to the UK overall, however, these trends have resulted in very little diversity in both RET capacity and output: insignificant biomass and offshore wind, although deployment of the latter should increase over the next decade or so.

Table 6.2 Capacity of, and electricity generated from renewable electricity sources 2002 to 2011 in Scotland (DECC, 2012c)

A Installed capacity (MW)

Year	Hydro	Wind [1]	Landfill gas	Sewage Gas	Other biomass [2]	Solar PV [3]	Total	Hydro as a % of total capacity	Wind as a % of total capacity	Wind as a % of annual new capacity
2002	1304	186	26	-	22	-	1538	85	12	-
2003	1299	308	48	-	21	-	1676	76	18	88
2004	1308	412	62	-	21	-	1802	73	23	83
2005	1312	747	72	-	21	-	2151	61	35	96
2006	1331	947	78	-	44	-	2399	55	39	81
2007	1340	1150	92	-	92	-	2674	50	43	74
2008	1444	1708	94	-	93	-	3339	43	51	84
2009	1456	2115	108	7	134	-	3820	38	55	85
2010	1459	2647	109	8	140	2	4365	33	61	98
2011	1489	3016	113	8	142	41	4810	31	63	83

B Generation output (GWh)

Year	Hydro	Wind [1]	Landfill Gas	Sewage Gas	Other biomass [2]	Solar PV [3]	Total	Hydro as a % of total generation	Wind as a % of total generation
2002	4,455	406	157	-	80	-	5,099	89	8
2003	2,902	449	228	-	146	-	3,725	78	12
2004	4,475	848	339	-	170	-	5,832	77	15
2005	4,612	1,281	395	-	197	-	6,486	71	20
2006	4,225	2,023	424	-	291	-	6,963	61	29
2007	4,693	2,644	487	-	403	-	8,226	57	32
2008	4,709	3,330	502	-	600	-	9,141	52	36
2009	4,864	4,558	534	21	778	-	10,755	45	42
2010	3,313	4,861	534	21	861	1	9,591	35	51
2011	5,332	6,984	507	35	863	8	13,728	39	51

Note : [1] Includes onshore wind, offshore wind and shoreline wave and tidal stream power. [2] Other biomass category same as defined for Table 5.1. [3] Sub-national data for solar PV was not recorded prior to 2010.

Reflecting the dominant contribution of hydro power and onshore wind, RES-E generation output in Scotland is especially exposed to variations in rainfall and wind speed. This can be seen by the drop in total generation output for the years 2003 and 2010, despite significant growth in deployment capacity. Although Scotland has 89 per cent of the UK's total installed hydro power, output for this technology also declined significantly, from 4,877 GWh to 3,267 GWh (-1,610 GWh) between 2009 and 2010. In contrast, however, onshore wind increased output in 2010. Although the data at the individual wind technology level is aggregated, it is clear that the bulk of the increase (+303 GWh) will be from onshore wind, reflecting the minimal deployment of offshore wind in Scotland. Reflecting the domination of both hydro and onshore wind in Scotland, although total biomass showed growth in output (but only +92 GWh), overall, total increases in output in Scotland (+395 GWh) was significantly offset by the decrease in total hydro power, resulting in a net generation decline of -1,215 GWh. This resulted in generation actually declining from 10,730 GWh (2009) to 9,515 GWh in 2010 despite net installed capacity increasing by +543 MW during the same period (Wood, 2010).

Table 6.3 (page 185) clearly highlights these trends by showing overall RES-E generation as a percentage of total electricity generation in the UK, Scotland, England, Wales and Northern Ireland for the period 2003-11. Categorised together, renewables have consistently shown positive year on year growth in overall generation output before 2009.[137] Post 2009, and as a consequence of the driest year since 2003, RES-E generation declined from a peak in 2009 of 20.9 to 19.1 per cent of electricity generation in 2010 (or 27.3 to 24.1 per cent of electricity consumption, the

[137] There are two insignificant exceptions for Wales (2006) and Northern Ireland (2010) where generation output declined by 0.1%.

Table 6.3 Overall renewable electricity generation as a percentage for the period 2003 to 2011 in the UK (Adapted from the Department for Business, Enterprise and Regulatory Reform [BERR], 2006; DECC, 2011a; 2012a; Scottish Government, 2011a; 2012)

	UK total	Scotland	Scotland [1]	Wales	N Ireland	England
2003	2.7	7.7	9 [2]	2.6	1.6	1.9
2004	3.6	11.6	14.1 [2]	3.1	2.0	2.3
2005	4.2	13.2	15.5	4.0	2.8	2.9
2006	4.6	13.3	16.9	3.9	3.4	3.1
2007	4.9	17.1	20.2	4.2	4.5	3.1
2008	5.5	18.0	22.0	4.3	6.4	3.6
2009	6.7	20.9	27.3	5.0	10.4	4.2
2010	6.8	19.1	24.1	5.1	10.3	4.7
2011	9.7	26.8	36.3			

Note: [1] The data in this column is different due to the fact that in Scotland, the renewables target is expressed as generation as a proportion of gross electricity consumption (defined as generation plus transfers into Scotland less transfers out of Scotland). The corresponding percentages for the UK as a whole are 4.2 (2005), 4.5 (2006), 4.9 (2007), 5.4 (2008), 6.6 (2009) and 6.7 (2010). [2] The Scottish Government, 2009. [3] This is a provisionary figure using 2010's gross consumption as a proxy for 2011 as data for 2011 is not published until December 2012.

measurement used by the Scottish Executive).[138]

6.3 Measuring the United Kingdom sectoral targets

The 2009 Renewable Energy Directive has set the UK a legally-binding target of supplying 15 percent of its gross final consumption of energy from renewable sources by 2020 (Europa, 2009).[139] In keeping with the sectoral approach adopted within the EU, the overall target has been split between the three major sectors: electricity, heating and cooling and transport. Table 6.4 (page 187) shows both the mandatory and indicative sectoral targets for the UK alongside the aspirational targets that the Scottish Government has set for Scotland. The UK government document '*UK Renewable Energy Strategy 2009*' (DECC, 2009c) first established that the overall 15 percent target would equate to 239 TWh total final energy consumption in 2020. At the sectoral level, renewable electricity would contribute 30 percent (or 114 TWh) to final energy consumption, 12 percent (72 TWh) from heating and cooling and 10% from transport (49TWh). In terms of the 15 percent target, electricity would account for the greatest proportion, almost half of the total (49 percent) with heating and cooling (30 percent) and transport (21 percent) comprising the remainder.[140]

[138] In contrast to the standard method utilised at the UK overall level and for the other countries to determine progress towards meeting the Renewables Obligation targets (renewable generation as a percentage of total electricity generation), RES-E generation in Scotland is alternatively measured as a proportion of gross electricity consumption when electricity transfers (imports and exports) are taken into account (the right-hand column of data for Scotland). This method results in significant differences between the two columns, given that Scotland can export over 10,000 GWh or 20-25 percent of total electricity generation in a year. It can also be particularly seen in the method by which the Scottish Executive expresses the Scottish RES-E targets (31 per cent in 2020 and 100 per cent equivalent in 2020).

[139] Section 15 of the Directive (2009/28/EC) on the promotion of the use of energy from renewable sources sets out the necessity of translating the European Community target of 20 percent for the overall share of energy from renewable sources into individual targets for each Member State due to variations in renewable energy potential and the energy mix of each Member State. The breakdown into national targets is set out in Annex 1 of the Directive. The Directive also established interim targets of 4 per cent (2011-12), 5.4 percent (2013-14), 7.5 percent (2015-16) and 10.2 percent (2017-18).

[140] These targets were further reiterated in the UK Low Carbon Transition Plan 2009 (DECC, 2009d), the UK Renewable Energy Roadmap (DECC, 2011f) and the UK Renewable Energy National Action Plan (DECC, 2010), the latter required under Article 4 of the European Renewable Energy Directive (2009/28/EC).

Table 6.4 Renewable energy and sectoral targets at the UK and sub-national level for 2020

	RED Target	Sectoral Targets [2]		
		Electricity	Heat	Transport
United Kingdom				
% of total energy	15% [1]	30%	12%	10%
% of renewable energy	-	49%	30%	21%
TWh	239	114	72	49
Scotland				
%	30%	100%	11%	10%
TWh	42 [3]	36 [4]	6.4	
GWe	–	16	2.07	

Note: [1] This is the only legally-binding target. [2] Sectoral targets are indicative only, and thus could potentially change over time. [3] Calculated using the target ambition of 139.5 TWh total energy consumption by 2020 in Scotland under the Energy Efficiency Action Plan 2010 (30% of 139.5 = 42 TWh) (Scottish Government, 2010a). [4] Estimate of the 100% RES-E target translated into TWh.

There are inherent difficulties in translating the target into installed capacity, particularly for those renewable electricity technologies that depend on the wind, solar or water resources. This is part of the reason underlying the variation for both the UK and Scottish targets when expressed as installed capacity. It is estimated that the UK requires around 35-40 GW of RET deployment capacity in order to achieve the sectoral target, equating to 30-34 percent of the target (DECC, 2009c). At the end of 2011, approximately 12 GW of RET capacity was installed. The equivalent Scottish target is between 16-17 GW, compared to around 5 GW of total current deployment in 2011 (equating to between 29 to 31 percent of the Scottish target).[141] Put in context, the UK and Scotland require between 22 to 27 GW and 11 to 12 GW, respectively. In order to meet the sectoral target, the required annual increase in deployment capacity for the UK is between 2.5 and 3.1 GW per annum. For Scotland, between 1.2 and 1.3 GW is required per annum.

As stated previously, the key RETs anticipated by the government to account for the majority of deployment to 2020 are: onshore wind (13 GW, requiring an increase of +8.4 GW by 2020), offshore wind (18 GW, requiring an increase of +16.2 GW by 2020) and biomass conversion and dedicated biomass (6 GW of biomass capacity is anticipated to be needed, requiring an increase of around +3.5 GW by 2020 of which around 75 per cent (or 2.6GW) would come from biomass conversion and dedicated biomass). This would equate to around 37 GW towards the 2020 sectoral target. However, caution is required in interpreting these '*capacity amounts*': they are modelled assumptions of potential deployment and not technology-specific targets nor indicative of the level of government ambition (although there is some uncertainty regarding this,

[141] In contrast to the UK, over the last two decades the Scottish Government has set a series of increasingly ambitious targets for both total renewable energy and renewable electricity: from 18 percent by 2010 (set in 2003) to 31 percent of gross electricity consumption by 2011 (see section 5.2, page 163). With regard to the 2020 target, originally this was set in 2003 at 40 percent of electricity consumption from renewables by 2020. Since then the target has been increased from 50 percent in 2007 to 80 percent in 2010. In 2011, the Scottish Executive declared a new target of 100 percent electricity demand (consumption) equivalent from renewables by 2020 (Scottish Government, 2011b). Currently, there is no sectoral target for transport. For heating and cooling, however, the target stands at 11 percent. A new target of at least 30 percent overall energy demand from renewables has also been set for 2020, an increase from the previous target of 20 percent (Scottish Government, 2011c). Indeed, Scotland has always generated more than the proportionate share of renewable electricity due to the historical deployment of hydro power.

in particular see chapter seven, section 7.3.2). They are also dependent on falling costs and whether or not the government is successful in addressing the internal and external failures to deployment. The rest of deployment presumably would come from the remaining RET options[142]: omitting the key technologies, there is currently 4 GW of installed capacity from the non-key RETs as of 2011.

Table 6.5 (page 190) shows the average annual deployment rates (in MW and as a percentage of total deployment) at the UK and Scottish level for the period 2002-11.[143] It is clear from Part A that average and actual annual deployment rates for the UK and Scotland both fall significantly short of this: the average annual deployment rate is +1,048 MW and +364 MW per annum for the UK and Scotland, respectively. This means that a step-change is required in terms of deployment. The UK has to almost treble the average deployment rate whilst Scotland has to quadruple its current average annual rate. Part A also highlights three main points: the required annual deployment has been achieved at the UK level only once (+3.1GW, in 2011); Scotland has never achieved the required amount, yet Scotland accounts for 41 percent of total UK annual average capacity; and deployment so far is heavily dependent on onshore and offshore wind (both RETs account for over two-thirds of total UK annual average deployment). Importantly, the 3.1 GW of deployment in 2011 was achieved due to increases in solar PV and biomass conversion, both RETs that had evidenced very little growth previously.

[142] The remaining RETs exhibit insignificant average annual deployment (small and large-scale hydro, sewage gas, co-firing, landfill gas and shoreline wave and tidal stream). The exception is solar PV; however, virtually all growth in capacity has occurred only during 2010-11.

[143] The point in highlighting average annual installed capacity (deployment) rates separately at the UK and Scottish level is not to pro rata the individual sub-national and national targets. However, it serves to illustrate deployment levels to date and the additional new capacity required to meet both the UK and Scottish targets. Further, Scotland has gained a degree of control over renewable energy as part of the devolution process. As the sovereign state, however, it is the UK that is required to meet the sectoral RES-E target as part of the legally binding EU 2020 renewable energy target. Sub-national differences in resource potential such as onshore wind in Scotland will have been taken into account in the setting of the UK target.

Table 6.5 Average annual deployment rates for key renewable electricity technologies at the UK and Scottish level

A

Country	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Overall Average
UK (MW)	371	386	931	492	600	1,007	1,247	1,207	3,187	1,048
Scotland (MW)	138	126	349	248	275	665	481	545	445	364
Scotland as a % of UK deployment	37	33	37	50	46	66	39	44	14	41
Total wind (MW)	207	191	632	389	523	930	1,018	954	1,110	662
Total wind as a % of UK total deployment	56	50	68	86	87	92	81	79	35	70

B

Onshore wind	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Overall Average
UK (MW)	148	131	542	299	433	737	663	554	613	457
Onshore wind as a % of UK deployment	40	34	58	67	72	73	53	46	19	51
Scotland (MW)	122	104	335	200	203	558	407	532	369	314
Scotland as a % of UK deployment	82	79	62	67	47	76	61	96	60	62
Offshore wind	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Overall Average
UK (MW)	59	60	90	90	90	193	355	400	497	204
Offshore wind as a % of UK deployment	16	16	10	19	15	19	28	33	16	19
Other biomass [1]	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Overall Average
UK (MW)	27	1	27	40	83	58	101	93	1,020	161
Other biomass as a % of UK total deployment	7	0.3	3	8	14	6	8	8	32	7

Note: Data taken from Tables 5.1 and 5.2 (see text). [1] Other biomass includes biomass conversion and dedicated biomass.

As stated previously, it is uncertain whether or not this trend will continue.[144] In contrast, total wind only accounted for approximately a third of deployment in that year.

Part B of Table 6.5 examines the average annual deployment of the key RETs. As expected from Part A, the average annual deployment rates for the key RETs fall substantially short of the required level: onshore wind (+457 MW per annum); offshore wind (+204 MW per annum); other biomass, including biomass conversion and dedicated biomass (+161 MW per annum). This equates to around +822 MW per annum.[145] At this rate of deployment, the UK would miss the target by approximately 50 percent. In other words, the UK needs to accelerate deployment of these key technologies up to 2020. This will depend on the UK government successfully addressing the internal and external failures that act to constrain deployment. Importantly, Scotland accounts for 62 percent of total UK onshore wind average annual deployment over the period 2002-11, emphasising the major role of onshore wind in that country and the critical contribution Scotland has with regard to the UK meeting the 2020 target.

However, there are a number of inter-linked assumptions inherent in the generation-based targets, both sectoral and overall. This has implications for the total installed capacity base required to meet the targets. Primarily, the targets are fundamentally based on the accuracy and therefore credibility that the 15 percent total renewable target will equate to 239 TWh in 2020. The most up-to-date projection for total energy consumption in 2020 is 1,590 TWh (DECC, 2010; DECC, 2011g), of which 239 TWh equates to 15 percent. With regard to the assumptions, firstly, there is no truly accurate way to establish the future level of consumption, due particularly to the variables upon which the projections are based, including but not exclusively, fossil fuel and carbon

[144] Despite being beyond the data cut-off point for this thesis, it is worth pointing out that although solar PV deployment has increased by +713 MW in 2012, in contrast plant biomass has declined by -829 MW due to the closure of Tilbury power station in 2013 (Business Green, 2013).

[145] These RETs include small and large-scale hydro, sewage gas, co-firing, landfill gas and shoreline wave and tidal stream.

price projections, cost estimates for the power sector, growth projections and policy and legislative action (at the sub-national, national, regional and international levels). These variables will vary over time and interact in complex and critical ways (DECC, 2011g). Second, the figure of 1,590 TWh is based on the UK achieving its ambitious energy efficiency targets across all sectors (DECC, 2010; Kelly, 2006). This means that the 15 percent target, or 239 TWh, equates to the actual *minimum* generation output from total renewables in the UK by 2020: if the energy efficiency measures are unsuccessful, and demand is not reduced, then renewable generation output will have to increase, proportionally. It is important to note, however, that the reasons mentioned above could also produce a positive effect on the target (for example, energy efficiency targets could be over-achieved), reducing the amount of renewable energy required.

With regard to the electricity sectoral target, uncertainty is further increased by the observation that if either of the two other sectors under-performs with regard to their specific targets, there is the possibility that renewable electricity will have to over-perform.[146] Currently, and for the last two decades, attention has focused primarily on renewable electricity.[147] In addition, in order for the current heating and cooling targets to be met, analysis has shown that a proportion of demand from both sectors will have to be met via the electricity sector (the electrification of heating and cooling and transport) with electricity demand expected to double (CCC, 2009; DECC, 2009c). Both points add uncertainty, and result in the fact that the sectoral targets, particularly for electricity, equate to the minimum possible target that must be achieved if the legally-binding 15 percent target is to be achieved.

---

[146] At the sectoral level, projections of total electricity consumption for 2020 are 377 TWh, with 599 TWh for heating and cooling and 486 TWh for transport.[146] As can be seen from Table 5.4, electricity comprises the smallest sector. As with the overall target, the sectoral projections include the UK achieving its energy efficiency measures, and the impact of the various variables on energy demand into the future.

[147] Total renewable generation output stood at 54 TWh in 2010 (3.3 percent of UK total energy consumption). Renewable electricity accounted for the largest amount by sector (25.7 TWh), whilst heating and cooling accounted for 14.1 TWh with provisional data for transport indicating 14.1 TWh (DECC, 2011f). Although there has been significant progress, particularly for the heat sector (e.g. the introduction of the Renewable Heat Incentive), the UK government views renewable electricity currently as the easiest, least cost option especially with regard to the approaching 2020 target despite the relatively small size of the electricity sector overall (DECC, 2009d).

The proposals included in the most recent Energy White Paper '*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011*' (DECC, 2011h), however, appear to change the role of the Renewables Obligation with regard to the 2020 sectoral RES-E target. The RO is now proposed to be vintaged and replaced by a Feed-in Tariff Contract for Difference (FIT CfD) mechanism in 2017. In addition, during the period 2014-17, the RO is anticipated to operate alongside the new mechanism. The relevance of these proposed changes to the target is that the UK Government now expects that the RO will contribute part of the installed capacity and generation output (80 TWh of large-scale RES-E generation by 2017) required to achieve the sectoral target of 114 TWh (DECC, 2012d). In other words, if these changes go ahead and on time, the RO will no longer be expected to achieve the target largely by itself. However, the current subsidy mechanism is expected to account for the majority of RES-E deployment/generation, approximately 75 per cent of the 2020 sectoral target. As such, the RO still remains critical to the achievement of the target. Emphasising this point, the replacement mechanism has still not been established in legislation and there are currently significant concerns regarding both the design and operation of the proposals and whether or not they will be legislated on time given the demanding timetable (Energy and Climate Change Committee, 2012).

As with the UK targets, the same critical assumptions and issues underlie the renewable energy targets set in Scotland. In contrast to the UK, however, the Scottish Executive has not translated the targets from percentages to a measurement of generation output, with the exception of renewable heat: 11 percent has been equated to 6.4 TWh (Scottish Government, 2011d). Targets for both renewable electricity and heat have, however, been translated into installed capacity, with 16 GW and 2 GW, respectively (Scottish Government, 2011c). Critically, the Scottish Executive has not established clear and thus credible projections for total energy demand in 2020. A review of the extant literature, however, reveals a number of disparate estimates for the RES-E sectoral target.

Projections for gross electricity consumption for Scotland by 2020 range from 36 to 44 TWh.[148] An examination of the various projections, however, show that the figure is likely to be around 36 TWh by 2020. Although this figure correlates closely with average statistics over a ten year period from 2001 to 2010 (DECC, 2006; DECC, 2011e) it appears to be based on the unfounded assumption of a growth in total consumption of around 10 percent. In relation to the specific target of '*100 percent electricity demand (consumption) equivalent from renewables by 2020*' this therefore means that this Scottish Executive is seeking to increase generation output to double that, to approximately 72 TWh by 2020. It is important to note that total renewable electricity generation for the UK overall in 2011 was around 33 TWh, of which renewable electricity generation in Scotland accounted for 13.7 TWh (although it should be noted that this was a record year due to higher than average rainfall and wind speeds increasing average generation output). This means that renewable generation will have to increase roughly three-fold over the next 9 years.[149]

Currently undefined, what does the 30 percent total renewables target actually mean in terms of generation output? The Scottish Government (2010a) document '*Conserve and Save: The Energy Efficiency Action Plan for Scotland*' states that the 2020 target maximum consumption of energy is 139.5 TWh. Providing a limit on total consumption, the 30 percent target would therefore equate to 42 TWh. Although the combined

---

[148] At the lower end, AEA in their report '*Energy Storage and Management Study*' (AEA, 2010) estimate gross electricity consumption by 2020 to be 36 TWh. In the report '*Coping with High Renewables Penetration in Scotland*', Garrad Hassan (2010) estimate estimates a figure of 43.7 TWh (however their study uses incorrect data for the baseline year – 40.9 GWh in 2008 instead of the actual figure of 35.4 TWh (see DECC, 2011e): utilising the same methodology onto the correct baseline data results in a figure of between 36-38 TWh, close to the AEA projections). In addition, the '*Draft Electricity Generation Policy Statement 2010*' by the Scottish Government (2010b) provides a figure of 28.9 TWh based on the previous RES-E target of 80 percent – if this is scaled up to 100 percent, it would increase to approximately 35 TWh. At the upper end, and in contrast to the draft electricity generation statement, in 2011 the SNP released a brochure clearly stating that total electricity consumption in Scotland by 2020 was estimated to be around 43.8 TWh (Scottish Government, 2011e). This represents a difference of over 8 TWh from the draft statement estimate and correlates closely with the erroneous figure by Garrad Hassan.

[149] Interestingly, a concomitant three-fold increase in renewable electricity installed capacity (from 4.8 GW in 2011) would equate to around 15-16 GW, showing a close correlation to the set target of approximately 16 GW. This is reasonable as most installed capacity by 2020 is likely to remain onshore wind. The previous 2020 target of 50 percent was calculated to comprise approximately 8.3 GW (Wood, 2010), with the interim target of 31 percent by 2011 equating to 5 GW (Scottish Government, 2008).

sectoral targets for electricity and heating and cooling equate to 42 TWh, the 30 percent overall target is defined as '*at least*' meaning that if and when the transport targets are able to be defined on a Scotland-only basis, the overall target will we undoubtedly higher (Scottish Government, personal communication).

As mentioned previously, the Scottish renewable energy targets are purely aspirational. They are not legislated for by the Renewable Energy Directive, and thus are not mandatory. The real significance of the highly ambitious RES-E target is that if achieved more or less on time, Scotland could contribute over 30 percent towards the UK electricity sectoral target total. This is important given that recent research has concluded that the UK would need between 6.6 and 11.4 GW of renewable electricity from Scotland to achieve its 2020 targets (Electricity Networks Strategy Group [ENSG], 2009).

References

4COffshore, 2011. Offshore Wind Farms Project Database [online] Available from http://www.4coffshore.com/windfarms/robin-rigg-united-kingdom-uk20.html

AEA, 2010. Energy Storage and Management Study: October 2010 [online] Available from http://www.scotland.gov.uk/Resource/Doc/328702/0106252.pdf

Business Green, 2013. RWE npower halts Tilbury biomass development [online] Available from http://www.businessgreen.com/bg/news/2279576/rwe-npower-halts-tilbury-biomass-development

Committee on Climate Change, 2009. Meeting Carbon Budgets – the need for a step change. Progress report to Parliament Committee on Climate Change 12 October 2009 [online] Available from http://www.theccc.org.uk/reports/progress-reports

Crown Estate, 2011. Our portfolio – Rounds 1 and 2 wind farms [online] Available from http://www.thecrownestate.co.uk/energy/offshore-wind-energy/our-portfolio/

Department for Business, Enterprise and Regulatory Reform (BERR), 2006. Digest of United Kingdom Energy Statistics (DUKES) 2005 [online] Available from http://www.decc.gov.uk/assets/decc/statistics/publications/dukes/dukes06.pdf

Department of Energy and Climate Change, 2006. Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2005: Special feature- Renewable energy December 2006 [online] Available from http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/articles_issue/articles_issue.aspx

Department of Energy and Climate Change (DECC), 2009a. Digest of UK energy statistics: 60th anniversary edition [online] Available from http://www.decc.gov.uk/assets/decc/statistics/publications/dukes/1_20090729135638_e_@@_dukes60.pdf

Department of Energy and Climate Change (DECC), 2009b. Energy Trends – December 2009 [online] Available from http://www.decc.gov.uk/assets/decc/statistics/publications/trends/1_20091222083326_e_@@_trendsdec09.pdf

Department of Energy and Climate Change (DECC), 2009c. UK Renewable Energy Strategy [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/renewable%20energy%20strategy/1_20090717120647_e_@@_theukrenewableenergystrategy2009.pdf

Department of Energy and Climate Change (DECC), 2009d. UK low Carbon Transition Plan: National strategy for climate and energy [online] Available from http://www.decc.gov.uk/publications/basket.aspx?FilePath=White+Papers%2fUK+Low+Carbon+Transition+Plan+WP09%2f1_20090724153238_e_%40%40_lowcarbontransitionplan.pdf&filetype=4#basket

Department of Energy and Climate Change (DECC), 2010. National renewable Energy Action Plan for the United Kingdom [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/25-nat-ren-energy-action-plan.pdf

Department of Energy and Climate Change (DECC), 2011a. Digest of United Kingdom Energy Statistics (DUKES) 2010 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/2312-dukes-2011--full-document-excluding-cover-pages.pdf

Department of Energy and Climate Change (DECC), 2011b. Energy Trends – September 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/2871-trends-sep11.pdf

Department of Energy and Climate Change (DECC), 2011c. Renewable Energy and STATisticS database: Historical Regional Statistics – 2010 Regional Data [online] Available from https://restats.decc.gov.uk/cms/historic-regional-statistics/

Department of Energy and Climate Change (DECC), 2011d. Renewables: Renewable electricity capacity and generation [online] Available from http://www,decc.gov.uk/assets/decc/Statistics/source/renewables/et6_1.xls

Department of Energy and Climate Change (DECC), 2011e. Energy Trends – December 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/3917-trends-dec-2011.pdf

Department of Energy and Climate Change (DECC), 2011f. UK Renewable Energy Roadmap [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change (DECC), 2011g. Updated energy and emissions projections – October 2011: Central Scenario [online] Available from http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3120-annex-e-total-electricity-gen-by-source.xls

Department of Energy and Climate Change [DECC], 2011h. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change (DECC), 2012a. Digest of United Kingdom Energy Statistics (DUKES) 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65881/5949-dukes-2012-exc-cover.pdf

Department of Energy and Climate Change (DECC), 2012b. Energy Trends [online] Available from https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-trends

Department of Energy and Climate Change (DECC), 2012c. Renewable Electricity – DECC data: Energy Trends, September and December – December 2012 [online] Available from https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-trends

Department of Energy and Climate Change [DECC], 2012d. Government response to the consultation on the proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: July 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Electricity Networks Strategy Group, 2009. ENSG 'Our Electricity Transmission Network: A Vision for 2020' Full Report [online] Available from http://www.ensg.gov.uk/assets/ensg_transmission_pwg_full_report_final_issue_1.pdf

Energy and Climate Change Committee, 2012. Draft Energy Bill: Pre-legislative Scrutiny: First Report of Session 2012-13: Volume I: Report, together with formal minutes – 17 July 2012 [online] Available from http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenergy/275/275.pdf

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Garrad Hassan, 2010. Options for Coping with High Renewables Penetration in Scotland [online] Available from http://www.foe-scotland.org.uk/sites/files/Garrad%20Hassan%20PoSS.pdf

Kelly, N. 2006. The role of energy efficiency in reducing Scottish and UK CO_2 emissions. Energy Policy 32(2006): 3505-3515.

RenewableUK, 2011. United Kingdom Wind Energy Database (UKWED) Statistics [online] Available from http://www.bwea.com/statistics/

RWE npower, 2012. Flexible power from biomass [online] Available from http://www.rwe.com/web/cms/en/1295424/rwe-npower/about-us/our-businesses/power-generation/tilbury/tilbury-biomass-conversion/

Scottish Government, 2008. News Release: Renewable energy targets [online] Available from http://www.scotland.gov.uk/News/Releases/2008/09/09103722

Scottish Government, 2009. Renewables Action Plan [online] Available from http://www.scotland.gov.uk/Publications/2009/07/06095830/0

Scottish Government, 2010a. Conserve and Save: The Energy Efficiency Action Plan for Scotland [online] Available from http://www.scotland.gov.uk/Publications/2010/10/07142301/16

Scottish Government, 2010b. Draft Electricity Generation Policy Statement 2010: Scotland – A Low Carbon Society [online] Available from http://www.scotland.gov.uk/Resource/Doc/331717/0107930.pdf

Scottish Government, 2011a. Energy Statistics Summary: December 2011 [online] Available from http://www.scotland.gov.uk/Resource/Doc/933/0124593.pdf

Scottish Government, 2011b. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011c. 2020 Routemap for Renewable Energy in Scotland [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0118802.pdf

Scottish Government, 2011d. Renewable Heat Action Plan for Scotland: a plan for the promotion of the use of heat from renewable sources [online] Available from http://www.scotland.gov.uk/resource/doc/290657/0089337.pdf

Scottish Government, 2011e. Renewables Overview [online] Available from http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/Energy
Scottish Government, 2012. Energy Statistics Summary: December 2012 [online] Available from http://www.scotland.gov.uk/Resource/0041/00411495.pdf

Wood, 2010. Renewable Energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020.CEPMLP Energy Series, CEPMLP: Dundee.

Part III
Applying the Systemic Approach

The analytical core of the thesis is contained in Part III and comprises three chapters. This part draws from both part I and II. Part I set out the rationale and justification for why this subject was chosen and the way in which the research has been conducted. This was to evaluate the current UK approach to large-scale renewable electricity technology deployment to 2020 and beyond by adopting a systemic approach framework to determine whether or not the UK will be successful in addressing the potential constraints – the internal and external failures – to deployment. In particular, the first two chapters of Part III build on the literature review in chapter three to investigate and analyse the recent policy, legislative and regulatory changes introduced to determine the internal (chapter seven) and external (chapter eight) failures of the current UK approach to addressing the constraints to deployment. Both chapters draw on Part II of the thesis which set out the context regarding large-scale renewable electricity technologies. Finally, in the third chapter of part III, the analysis of the internal and external failures is then synthesised to reveal the systemic interactions of the constraints.

Chapter seven is concerned with evaluating the internal failures on large-scale renewable electricity technology deployment. This is done by examining the reformed Renewables Obligation (2009 onwards) in order to determine what the internal failures are. Chapter eight is concerned with evaluating the external failures on large-scale renewable electricity technology deployment. This chapter is split into four main sections reflecting the four external failures examined in this thesis. Section 8.2 focuses on the planning system in England and Scotland in light of recent legislative and policy changes. Section 8.3 looks at the opportunities and barriers facing public participation and engagement, with a focus on meso-scale developments and community and locally-owned projects. Section 8.4 examines the issue of network capacity and the method of allocation and access to the electricity network with emphasis on the transmission network. This section looks in particular at both the onshore and offshore transmission systems in the UK overall with particular emphasis on Scotland. Section 8.5 focuses on policy risk with a particular emphasis on the various large-scale renewable electricity subsidy mechanisms (the Renewables Obligation and the proposed Contracts for Difference Feed-in Tariff in so far as it affects deployment under the RO mechanism).

To ensure the analysis is rigorous, credible and transparent, both chapter seven and eight follow the first two criteria set out in the methodology chapter (chapter two). It investigates a comprehensive set of internal and external failures that capture the significant constraints that affect deployment. Further, it analyses the constraints in sufficient depth. This will permit the identification of the systemic interactions of the internal and external failures in order to evaluate the current UK approach to addressing these constraints to large-scale renewable electricity technology deployment carried out in chapter nine.

Chapter nine utilises the analysis of both the internal and external failures presented in chapters seven and eight, respectively, to reveal the systemic interactions of the potential constraints examined here. This will be done in order to evaluate the current UK approach to addressing the potential constraints to large-scale RES-E deployment from a systemic perspective.

It is also important to keep in mind that renewable electricity technologies are also highly heterogeneous, exhibiting a range of different technical, economic, environmental, and social attributes that are strongly dependent on the type of renewable electricity technology down to the sub-category level. Therefore, each of the different technologies is affected by the internal and external failures in different ways. This has particular implications for the deployment of these technologies.

Chapter Seven

Chapter Seven
Potential constraints I: Internal Failures

7.1 Introduction

This chapter is concerned with evaluating the internal failures on large-scale renewable electricity technology deployment. The focus of the chapter is to examine the RO and the changes introduced by the 2009 reform along with subsequent reforms to the subsidy mechanism.

Section 7.2 provides a background to the current situation regarding large-scale renewable electricity technology subsidy mechanism support. This is done in order to highlight the recent changes to the promotion of small and large-scale renewable electricity technology deployment in the UK, and the proposal to replace the RO with the novel Contracts for Difference Feed-in Tariff mechanism. Section 7.3 provides an up-to-date explanation of the state of the reformed RO and the proposed changes set out in the most recent banding review and subsequent reforms in order to determine the internal failures. This sets out the government's current approach to addressing these potential constraints to large-scale renewable electricity technology deployment. Section 7.4 involves an evaluation of the internal failures with regard to deployment.

7.2 Background to renewable electricity support mechanisms

The UK has operated a specific subsidy delivery mechanism for the generation of electricity from renewable energy sources since 1990. There have been three main policy instruments: the Non-Fossil Fuel Obligation (NFFO) from 1990 to 1998, the Renewables Obligation (RO) from 2002 until 2009 and the reformed RO (rRO) from 2009 onwards (Mitchell *et al.*, 2006; Wood and Dow, 2011). Each mechanism ran more or less in isolation for a discrete period of time.[150] In addition, there are parallel

[150] In other words, at the end of the NFFO period (1998-99) all new contracts were awarded under the incoming RO mechanism, with the same occurring under the RO/rRO transition (Wood and Dow, 2011).

mechanisms now in operation. What is notable in terms of the operation of the parallel subsidy mechanisms is that they are either differentiated by type of sectoral support (for the heat/cool or transport sectors) or by scale. Regarding the latter, the small-scale feed-in tariff for RES-E generation is differentiated from support for large-scale generation by the determination of a cap in installed capacity of between 50 kWe and 5 MW (DECC, 2010a).[151] Large-scale renewable electricity policy in the UK, however, is moving towards a rather unique position.

Currently the main financial mechanism by which to subsidise and therefore enable RES-E generation to compete with fossil fuel generation, the rRO is expected to close to new generation from 31 March 2017. After this date, new renewable generation will be supported by the proposed Feed-in Tariff Contract for Difference (FIT CfD) scheme for low carbon technologies (nuclear, carbon capture and storage and large-scale renewables). This contrasts with the previous renewables only approach. Although the UK has at least limited experience with feed-in tariff style mechanisms, the FIT CfD represents a novel variant of the more typical FIT mechanisms used for domestic small-scale generation and for RES-E internationally. Furthermore, it is expected that there will be a lengthy transition period, between 2013/14 and 2017, where new generation will be able to choose between accrediting under the rRO or the FIT CfD (DECC, 2011a, b). Put simply, two mechanisms with the same purpose (to support large-scale RES-E generation) but fundamentally different design will be operating at the same time within the UK with the novel and untested mechanism ultimately anticipated to take over the role of promoting renewable generation just three years before the target deadline.

Of course, projects commenced under previous mechanisms would still obtain the level of subsidy agreed and would be bound by the particular design context of the mechanism in question. It should also be pointed out that the various mechanisms were not implemented contiguously: there was a hiatus between the NFFO/RO of around 4 years (Edge, 2006).

[151] Under the transition arrangements established with the introduction of the FIT mechanism for installations with an installed capacity of under 5 MW, certain RETs (onshore wind, hydro, anaerobic digestion and solar photovoltaic) could accredit under either the FIT or the RO mechanisms,

Importantly, according to what was initially meant to be a final consultation on the level of technology banding subsidy covering the final banding period (2013-17) after which it will be vintaged, the rRO is expected to contribute around 80 TWh/year of large-scale renewable electricity generation by 2017 (DECC, 2012a). In other words, despite the proposed change in mechanism, the rRO is anticipated by the government to account for the majority of RES-E deployment/generation, approximately 75 percent of the 2020 sectoral target, with additional RES-E generation presumably coming from the new FIT CfD and the small-scale FIT mechanisms.[152]

These fundamental changes to the way in which RES-E is subsidised will occur at the same time that the UK is poised to commence an unprecedented deployment of renewable electricity technologies within a very short space of time to meet the 2020 sectoral target. There will also be an equally unparalleled requirement in major upgrade and extension of the electricity transmission (both onshore and offshore) and distribution networks, not only in physical infrastructure but also in the design and function of the network towards smart grid and metering (DECC, 2009a; DECC, 2011c; OFGEM, 2010).[153] Analysis indicates that up to £110 billion investment in electricity generation and transmission is likely to be required by 2020 alone.[154] Therefore, the operation of the subsidy mechanism in terms of delivering the scale of long-term investment needed at the required pace is critical to a number of policy goals, including

---

[152] The anticipated contribution of the RO (around 80 TWh/year by 2017) is based on modelling by Pöyry (2011) in the report '*Potential Impact of Revised Renewables Obligation Technology Bands*' commissioned by DECC. The data and assumptions in the report were derived primarily from the Arup (2011) review into the generation costs and deployment potential of renewable electricity technologies commissioned by DECC .

[153] The UK electricity (and energy) sector is also undergoing considerable change with significant and wide-spread future implications: in addition to the legally-binding renewable and climate change (decarbonisation) targets, there are requirements for a major energy infrastructure replacement programme with the closure of approximately 20% of the UK's electricity generating plant over the next decade or so (DECC, 2011b). Such replacement could require as much as 20-30 GW new installed capacity dependent on the choice of technology (Helm et al., 2009). However, not all of the new generating plant will be renewables, given investment in nuclear, gas and CCS technologies, and nor will all the network infrastructure be solely for renewable electricity usage *per se*.

[154] Analysis carried out by DECC (2011b) and OFGEM (2010) show that around £75 billion could be required for new electricity generation capacity and around £35 billion of investment in the overall electricity transmission and distribution networks.

renewable energy, climate change and domestic and export markets and employment growth.[155] However, the success of the mechanism with regard to meeting the sectoral target will not be determined purely in terms of whether or not the internal failures will constrain deployment. This will also be determined by the external failures notably planning, grid, supply chain, policy risk/uncertainty and public participation and engagement (see chapter eight on the external constraints), and importantly, the systemic interaction between the internal and external failures (see chapter nine).[156]

It should also be noted that renewable electricity technologies are a distinctly heterogeneous category. As chapter five showed, such technologies are at different levels of research, development and deployment and exhibit multiple characteristics that relate directly to their relative potential to contribute to the 2020 sectoral target (and beyond). What is currently clear is that RETs are typically more expensive than non-renewable electricity technologies. The result of this is that for the time being the subsidy mechanism is critical to enable uptake by the market. This chapter will therefore examine the 'mechanics' of the rRO in detail. Given the lengthy transition period, and the expectation that the proposed FIT CfD will replace the current main mechanism, where relevant the FIT CfD will also be examined in this part of the thesis. To reiterate, internal (or structural) failures are barriers due to the design of the subsidy mechanism used to promote renewable electricity deployment. This category includes the type of promotional mechanism and how it operates, for example, what impact does the mechanism have on financial/investment risk. Other constraints in this category include mechanism operational lifetime (subsidy programme and/or subsidy duration) and mechanism complexity (see chapter two, in particular section 2.3 and Table 2.1 for more detail on the internal failures).

[155] Indeed, as discussed previously, the scale of the investment requirements is one of the major reasons for the electricity market reform process and, in particular, the proposed introduction of the new FIT CfD mechanism (see chapter one).

[156] The external failures will be looked at in more detail in chapter eight.

7.3 The internal failures of the reformed Renewables Obligation

The Renewables Obligation came into force in 2002 in order to support the generation of electricity from renewable electricity sources in the UK (OFGEM, 2011a).[157] Due to the substantial existing and expected contribution of RES-E in Scotland towards UK-wide renewable electricity generation, it is also important to look not just at the UK Obligation but also the Scotland-specific ROS where relevant (DECC, 2011d; Electricity Networks Strategy Group [ENSG], 2009; Scottish Government, 2011a). Although overall energy policy is reserved to the UK Government, with regard to Scotland in practical terms substantial areas of energy policy is devolved or under the control of the Scottish Government. Devolved energy matters include the promotion of renewable energy and energy efficiency, consents for new electricity generating plant and transmission lines, planning and building regulations, environmental regulation, climate change, fuel poverty and transport (Scottish Government, 2009a). Decisions regarding the operation of the Renewables Obligation Scotland are for the Scottish Government. Under the ROS, the Scottish Government also has the power to offer technology banding subsidy levels that differ from the overall UK approach in addition to other powers (see below).[158]

The current RO has not remained the same since its original implementation over a decade ago. Since 2009 there have been three major 'waves' of alterations to large-scale RES-E generation subsidy in terms of the overall RO mechanism design along with numerous revisions to both the structure of components of the mechanism and the level of subsidy offered to renewable electricity supply technologies: the consultation

[157] The term RO will be used throughout the dissertation to encompass all three Obligations unless specified otherwise where appropriate.

[158] Regarding energy matters, Scotland has more devolved powers than Wales or Northern Ireland regarding the Renewables Obligation. For example, although nuclear power (and fossil-fuel power) is a reserved energy matter for the UK Government, decisions over new build ultimately lie with the Scottish Government due to the devolved planning powers, in particular Section 36 of the 1989 Electricity Act (National Archives, 1989). This means that the national administration can and has effectively vetoed new nuclear build in Scotland (Scottish Government, 2007). In contrast, Wales has no such equal power over planning: "*While we continue to believe it is anomalous that consents for large power stations are executively devolved to Scotland and not Wales…*" (Welsh Assembly Government, 2010: 11). However, the devolved administrations cannot change the type or the fundamental operation of the mechanism (for example, from rRO to FIT CfD or the introduction of changes such as banding or headroom mechanism).

document '*Renewable Energy: Reform of the Renewables Obligation – May 2007*' (Department of Trade and Industry [DTI], 2007) that came into effect on 1 April 2009; the 1 April 2009 reform of the RO, the subsequent changes as part of the '*Consultation on Renewable Electricity Financial Incentives*' (DECC, 2009b, c) that came into effect on 1 April 2010; and the on-going proposals in the '*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011*' (DECC, 2011b) in conjunction with the '*Consultation on proposals for the level of banded support under the Renewables Obligation for the period 2013-17*' (the Banding Review) (DECC, 2012a). In particular, the latter two documents will have substantial implications not only for the RO mechanism but the way in which RES-E is fundamentally supported in the UK in the future.

Table 7.1 (pages 209-211) shows the current subsidy levels for those renewable electricity technologies supported under the rRO/ROS and the future levels for the period 2013-17 as set out in the first statutory banding review of the mechanism (DECC, 2012a; Scottish Government, 2012a). The period covered by the review runs until the mechanism is proposed to be vintaged and no longer open to new projects.[159] When technology banding was originally introduced in April 2009 to provide differentiated levels of support for different technologies, the reasoning underlying the design of the banding structure and the allocation of the individual RETs was based primarily by assessing the expected current and forward costs over the next few years for each technology (Wood and Dow, 2011). The principal costs were defined as capital and fuel costs and the findings of this cost-benefit analysis were then utilised in modelling the

---

[159] Although the data cut-off point for this thesis is 31 December 2011 (see Chapter One, Section 1.7 for the reasoning behind this date), both the UK Government and the Scottish Executive recently published their responses and final decision on changes to the rRO/ROS mechanisms, respectively (DECC, 2012a, b; Scottish Government, 2012a). Given the importance and potential impact of such changes, the inclusion of this data beyond the 2011 cut-off point is deemed necessary and justifiable. It should be pointed out, in addition, that the governmental responses did not overall deviate significantly from the position proposed in the original consultations published in 2011 (DECC, 2011a; Scottish Government, 2011b).

Table 7.1 Subsidy support levels for renewable electricity technologies under the Renewables Obligation and Renewables Obligation Scotland (2012-2017)

RETs	Level of support (subsidy) in ROCs per MWh: Current support 2012-13	Future support (2013-17): 2013-14	2014-15	2015-16	2016-17	Proposed changes [1]
Wind power						
(a) Onshore wind	1	0.9	0.9	0.9	0.9	Closure of band to new projects <5 MWe. New call for evidence on costs in September 2012.
(b) Offshore wind	2	2	2	1.9	1.8	
(c) Floating/Innovative	-	-	-	-	-	New consultation proposals are being introduced.
Hydro power	1	0.7	0.7	0.7	0.7	
Under the ROS	1	1	1	1	1	
Landfill gas						
(a) Open landfill sites	0.25	0	0	0	0	
(b) Closed landfill sites	-	0.2	0.2	0.2	0.2	New bands for closed landfill sites and Waste Heat to Power.
(c) Waste Heat to Power (at open and closed sites)	-	0.1	0.1	0.1	0.1	
Sewage gas	0.5	0.5	0.5	0.5	0.5	New consultation proposals are being introduced.
Solar PV	2	2	2	1.9	1.8	Banding proposals subject to re-consultation.
Advanced conversion technologies						
(a) Standard gasification	1	2	2	1.9	1.8	One advanced conversion technology (ACT) band supporting standard and advanced ACTs at the same ROC level.
(b) Standard pyrolysis	1	2	2	1.9	1.8	
(c) Advanced gasification	2	2	2	1.9	1.8	
(d) Advanced pyrolysis	2	2	2	1.9	1.8	

Table 7.1 (Continued)

Marine RETs						
(a) Wave	2	5	5	5	5	New consultation proposals are being introduced.
(b) Tidal stream	2	5	5	5	5	5 ROCs up to a 30 MW project cap. 2 ROCs above for both Wave and Tidal stream.
(c) Tidal barrage (<1 Gwe)	2	2	2	1.9	1.8	
(d) Tidal lagoon (<1 Gwe)	2	2	2	1.9	1.8	
Geothermal						
(a) Geothermal	2	2	2	1.9	1.8	New consultation proposals are being introduced.
(b) Geopressure	1	1	1	1	1	New consultation proposals are being introduced.
Biomass and waste						
(a) Anaerobic digestion	2	2	2	1.9	1.8	
(b) Biomass conversion	1.5	1	1	1	1	New band established (previously un-banded).
(c) Biomass conversion + CHP	2	1.5	1.5	-	-	Close band to new accreditation (April 1st 2015).
(d) Dedicated biomass	1.5	1.5	1.5	1.5	1.4	New consultation proposals are being introduced.
Under the ROS	1.5	1.5	1.5	1.5	1.4	Capacity ceiling of 10 MWe for wood-fuelled stations with CHP. New consultation proposals are being introduced.
(e) Dedicated biomass + CHP	2	2	2	-	-	Close band to new accreditation (April 1st 2015).
(f) Dedicated energy crops	2	2	2	1.9	1.8	Changes to definition of energy crops.
(g) Dedicated energy crops + CHP	2	2	2	1.9	1.8	Changes to definition of energy crops.
(h) Energy from waste + CHP	1	1	1	1	1	
Co-firing						
Co-firing (standard)	-					
(a) Solid/gaseous biomass (<50%)	0.5	0.3	0.3	0.5	0.5	Subject to further consultation.
(b) Bioliquids (<100%)	0.5	0.3	0.3	0.5	0.5	Subject to further consultation.
Co-firing (enhanced)						
(c) Mid-range (50-85%)		0.6	0.6	0.6	0.6	New band established (previously un-banded).
(d) High-range (85-100%)	0.5	0.7	0.9	0.9	0.9	Subject to further consultation (new cost control

Table 7.1 (Continued)

(e) Co-firing (standard) + CHP	1	1.5	1.5	-	-	0.5 ROC uplift only available to new accreditations until 31 March 2015. Band closed from 1 April 2015.
(f) Co-firing (enhanced) + CHP	-	1.5	1.5	-	-	New band established (previously un-banded). 0.5 ROC uplift only available to new accreditations until 31 March 2015. Band closed from 1 April 2015.
(g) Co-firing energy crops (standard)	1	1.5	1.5	1.5	1.5	No 0.5 ROC uplift for mid & high-range co-firing (50-100%). Band to be closed subject to consultation.
(h) Co-firing energy crops (std) + CHP	1.5	2	2	2	2	Band not available for mid & high-range co-firing (50-100%). Close band to new accreditation (April 1st 2015). Band to be closed subject to consultation.
Microgeneration [2]	2	2	2	1.9	1.8	New consultation proposals are being introduced.

Note: Data taken from the most recent publications (DECC, 2012a; Scottish Government, 2012a). Yellow bands signify ROS only changes to mechanism or subsidy level when different to the UK-wide RO. [1] Proposed changes includes either future agreed changes that will come into effect at a designated date or further consultations in the pipeline. See text for more detail concerning the proposed changes. [2] Certain microgeneration technologies are included here as they currently continue to fall within either the RO/ROS or small-scale FIT mechanisms under existing transition arrangements when the FIT was originally implemented in April 2010 (DECC, 2009a).

electricity market.[160] The consultation document '*Renewable Energy: Reform of the Renewables Obligation – May 2007*' (DTI, 2007: 13) stated that:

> "*We have found that these costs seem to fall into loose groupings which reflect at least in general terms the market and technological development that the technologies have reached to date. We are, however, also aware that there is a considerable degree of uncertainty over cost predictions… Given these uncertainties, the Government does not think it appropriate to make fine distinctions between the levels of support given to different technologies but rather to take groups of technologies and set support levels which reflect the general position of that group.*"

This led to the five banded (or seven technology bands in the case of Scotland) structure after the RO reform: Established Band 1 and 2 (low risk/mature technologies: landfill gas (band 1, 0.25 ROCs/MWh), sewage gas, co-firing of non-energy biomass (band 2, 0.5 ROCs/MWh), Reference (1 ROC/MWh: relatively mature technologies but requiring significant capital investment: onshore wind, hydro-electric, co-firing of energy crops, energy from waste), Post-Demonstration (1.5 ROCs/MWh: relatively immature technologies with the potential to undergo large-scale deployment in the near future: dedicated regular biomass), Emerging (2 ROCs/MWh: very immature high-risk technologies: offshore wind, solar photovoltaic, geothermal, marine renewables (RO-only), dedicated biomass energy crops and regular biomass with CHP, microgeneration) and Enhanced Band 1 and 2 (the same as Emerging but only operational under the ROS mechanism for wave and tidal stream technologies: tidal stream (band 1: 3 ROCs/MWh) and wave power (band 2: 5 ROCs/MWh).[161]

---

[160] Ernst and Young (2007) carried out the initial analysis and informal consultation on current and future costs and Oxford Energy Research Associates [OXERA] (2007) undertook the modelling. Both were commissioned by the UK Government.

[161] The initial subsidy level for the technology bands set in 2009 is contained in Schedule 2 (Electricity to be stated in ROCs) Part 2 (covering Articles 27(4), (5) and 33(3) of the Renewables Obligation Order 2009 (ROO 2009), the secondary legislation provided for in the Electricity Act 1989 as amended by the Energy Act 2008 (the primary legislation). Although examples of where RETs have had a subsequent change in subsidy level is examined later in this section, such examples are due to the triggering of emergency banding criteria or more recently under the scheduled banding review (see below).

It is clear from the number of current bands that the position has changed from a general, loose grouping of technologies to a more detailed distinction in the differentiated levels of support offered under the rRO. As of 2013-14 there will effectively be ten bands with the number changing throughout the period up to 2017.[162] With a limited number of exceptions, four significant points can be drawn from the data in Table 7.1: (1) Subsidy levels for the majority of RETs decline between 2012-17 or to a lesser extent remain constant over the period; (2) A cap in subsidy level linked to offshore wind has effectively been introduced with the exception of marine renewable technologies (see below); (3) Rules governing biomass electricity and waste have been tightened up, particularly in relation to sustainability and cost issues; and (4) There is the prospect for further changes to the RO mechanism.

Regarding the first point, those technologies that are in effect being banded down during the overall period up to 2017 include onshore wind, offshore wind[163], hydro power (although this is only for the RO and not the ROS where the subsidy level will remain unchanged), landfill gas, solar photovoltaic, advanced conversion technologies (only advanced gasification and pyrolysis), tidal barrage and tidal lagoon, geothermal, microgeneration and all biomass electricity and waste RETs with the exception of dedicated biomass with CHP (the subsidy level will remain constant until 1 April 2015 when the band will close to new accreditation), energy from waste (subsidy level will remain constant) and biomass co-firing standard including solid/gaseous biomass (<50 percent) and bioliquids (<100 percent) where the subsidy level will, despite temporarily fluctuating downwards, remain overall the same.[164] Not all RETs, however, exhibit a reduction in subsidy at the same time or rate (see Table 6.1).

---

[162] There will be effectively 13 technology bands as designated by differentiated levels of support for different RETs by the closure of the RO in 2016-17 (if no further changes occur which is unlikely given the number of new consultations proposed for RO-eligible technologies, see below).

[163] Although offshore wind is banded down during 2013-17, the Government previously consulted in 2009 to reduce the subsidy from 2 to 1.5 ROCs per MWh output from 1 April 2015 (DECC, 2009b). Therefore, it can be argued that this technology has effectively been banded up.

[164] With the exception of wave and tidal stream and most co-firing technologies, it is notable that all the other RETs included in the '*UK Renewable Energy Roadmap*' (DECC, 2012c) are effectively banded down in the period remaining until the RO is vintaged. This is despite the fact that the roadmap stated that such technologies (including onshore wind, offshore wind and non co-firing biomass electricity and waste

Alongside the reduction or stabilisation in subsidies for the majority of RETs, the government has set a cap on the maximum number of ROCs per MWh output linked to offshore wind (2 ROCs/MWh until 2014/15, 1.9 ROCs/MWh in 2015/16 and 1.8 ROCs/MWh in 2016/17). In other words, offshore wind is the marginal cost of meeting the 2020 RES-E sectoral target:

> "*As offshore wind remains the marginal technology, we would reduce the maximum ROC level for all technologies in line with the reductions for offshore wind – i.e. in 2016/17 no new accreditations should receive more than 1.8 ROC.*" (DECC, 2011a: 11).

Wave and tidal stream represent the only exception. At the UK level both marine RETs will be banded up to 5 ROCs per MWh output in line with the existing subsidy level under the ROS since 2009.[165] This maximum subsidy level, however, is dependent on the generating capacity being installed and operational by 31 March 2017 and only for those installations with an installed capacity of up to 30 MW accredited from 1 April 2012 to 31 March 2017. Those projects above the capacity cap will be awarded 2 ROCs/MWh and thus will not be linked to changes in the subsidy level offered to offshore wind.

With the exception of biomass co-firing standard (see above), all other co-firing technologies will evidence increases in subsidy during the period. This is in contrast to all other RETs except for wave and tidal stream (see above), and in a similar vein to these technologies, the increases are subject to a number of conditions that varies depending on the type of co-firing technology. Biomass co-firing enhanced high range (85-100%) will be subject to further consultation with the proposal to introduce a cost control mechanism with the intention by government to implement such a mechanism

---

technologies would account for the major contribution of the renewable energy required to meet the 2020 sectoral target (see Section 7.3.2).

[165] In actual fact marine renewables received the equivalent support level of 5 ROCs per MWh output since 2006 under the Marine Supply Obligation (MSO). The MSO was closed with the introduction of technology banding as part of the RO reform in 2009 (Wood, 2010).

in time for the 2014/15 Obligation period.[166] Where either biomass co-firing standard or enhanced RETs are deployed in-conjunction with CHP, the proposed increase in ROC uplift (from 1 to 1.5 ROCs/MWh) will only be available to new accreditations until 31 March 2015. Thereafter, both bands will be closed from the start of the next Obligation year. Regarding biomass co-firing energy crops standard with and without CHP, the proposed increase in ROC uplift (the same as for biomass co-firing standard or enhanced with CHP) will not be available for mid and high range (50-100%) technologies. In addition, consultations are forthcoming with the proposal to close both such technology bands.

As can be seen from the above discussion, both the UK Government and the Scottish Government have introduced new and at times diverging conditions on the use of bioenergy and waste. Such alterations to the mechanism are primarily due to reasons of sustainability and cost. As the 'UK Bioenergy Strategy' (DECC, 2012d: 58) states, the aim is that of "*Promoting cost and carbon-efficient biomass electricity… through the Renewables Obligation Banding Review consultation.*" Importantly, the co-firing cap which was initially set at the time of the 2009 RO reform will be removed for both the RO and the ROS.[167] In addition, there are further proposals either in the process of consultation or proposed for future consultation (see below). This has driven the changes to co-firing: in general, higher subsidy levels have been offered to those technologies that use limited energy crops with or without CHP and those RETs that utilise increased percentages of biomass in the co-firing process. In contrast, although

[166] Although not implicitly set out in the Government response (DECC, 2012a), the document does states the intention to take action to control spending on biomass conversion if the rate of uptake of this RET is higher than anticipated. This could take the form of the cost control mechanism suggested for biomass co-firing enhanced high range.

[167] During the 2007 consultation on reforming the RO the Government initially intended not to impose a cap on co-firing. Instead an emergency banding review trigger was included in the event that co-fired ROCs surrendered accounted for more than 10% of the total Obligation at any given time (Department of Trade and Industry [DTI], 2007). This was retained but a 10% cap was implemented after further analysis and the fact that co-firing was banded up (from 0.25 to 0.5 ROCs/MWh output during the consultation process (Department of Business Enterprise and Regulatory Reform [BERR], 2008; Oxford Energy research Associates [OXERA], 2007). Subsequently the co-firing cap was increased to 12.5% (OXERA, 2009). The primary reason for introducing the cap in the first place was potential volatility in the volume of co-firing and the effect this would have on other RETs and the stability of the ROC price overall (DTI, 2007).

the majority of co-firing RETs have increased subsidy levels (though with strict conditions), most bands will either close from 1 April 2015 or are subject to consultations on whether or not the band in question should be closed. In addition, those co-firing technologies with the potential for significant and rapid deployment potentially face the implementation of cost control mechanisms at a later date. There are also changes to the definition of energy crops. The major difference between the RO and ROS is that of dedicated biomass. The UK proposal is whether or not to introduce a supplier cap and introduce new minimum emission standards. This would exempt qualifying CHP plants. In contrast, the Scottish approach is to propose to introduce a 10 MW capacity ceiling for large-scale wood-fuelled stations without qualifying CHP plant.

Both the UK Government and Scottish Executive decisions on the RO also include a significant number of future consultations to be carried out that will bring additional changes. The UK Government is re-consulting on 10 different areas including the closure of bands, introducing a supplier cap for dedicated biomass and a cost control mechanism for co-firing and biomass conversion, excluding solar PV from the RO for new projects at or below 5 MW installed capacity and changing the level of support for a number of RETs including standard co-firing, onshore wind and solar photovoltaic. The Scottish Executive is re-consulting on 8 different areas.[168] Table 6.1 shows which technologies will be subject to further consultation under the RO mechanism. Despite the conclusion of the Banding Review in July 2012, the UK Government has already announced a U-turn on holding a consultation into excluding new small-scale generators from the RO mechanism from 1 April 2013. This would have left these RETs (including solar photovoltaic, anaerobic digestion, onshore wind and hydro with an installed capacity of between 50 kW and 5 MW) under the small-scale FIT (DECC, 2012a). In the case of solar PV, however, the Government has announced its intention to re-consult on excluding only solar PV from sub-5 MW RO support.

[168] Given the similarity between the three Obligations and the deliberate policy to keep the RO, ROS and NIRO as similar as possible, the majority of the Scottish Executive's additional consultations are the same as those put forward for the RO. Differences are discussed in text.

Table 7.2 (page 218) summarises the major structural components of the reformed RO and the key differences in the ROS. An important component of the 2009 reform of the RO is the banding review process to determine changes in subsidy support levels over time to reflect changes in RE costs and other market developments and the process for setting the bands during future review periods (or emergency reviews, see below). Both of these are critical in order to maintain a stable and predictable system for investors and developers. The key point regarding the review process was that it was set to occur on a time basis rather than being triggered by the deployment of a particular volume of generation capacity being reached. Although the secondary legislation, in this case the Renewables Obligation Order 2009 (ROO 2009) (National Archives, 2009) legislates for the first banding review to occur in October 2010 and to occur at subsequent four yearly intervals[169], changes to the level of support for RO-eligible RES-E are set out in primary legislation: Section 32D (4) of the Electricity Act 1989 as amended by Section 37 of the Energy Act 2008 (National Archives, 1989, 2008). The statutory factors required by law when the Secretary of State carries out a banding review include: : taking into account full project costs (planning, construction, capital, transmission and distribution), income (wholesale price of electricity, avoided costs of the EU Emissions Trading Scheme (EU ETS), Climate Change Levy, Landfill Tax), the desirability of securing the long-term growth and economic viability of the industries associated with RES-E generation, supporting the aim to maximise deployment in a sustainable manner and the potential contribution of RES-E to the attainment of any energy target from the EU.[170]

Section 33(3) of the ROO 2009 also provides for an (emergency) review of all or any banding provisions at any time if the Secretary of State is satisfied that the conditions

[169] The frequency of banding reviews was originally linked to planned changes in the EU ETS scheme, expected to be the 1 April 2013 and 1 April 2018 with any changes to be announced 18 months prior to the introduction of such changes specified in the banding review. With the proposed closure of the rRO to new capacity from 2017 in line with the Electricity Market Reform and the introduction of FIT CfD mechanism, however, the review process has been brought forward by almost a year (DECC, 2012a).

[170] See Part 2 – Electricity from renewable sources - Section 32D (1) to (4) for the relevant provisions in the Energy Act 2008 (National Archives, 2008).

Table 7.2 The major structural components of the reformed renewables obligation (RO) and renewables obligation scotland (ROS)

1. Banding

(a) Ten technology bands effectively established

(b) Technologies with similar costs (based on an assessment of expected current and forward costs over the next few years for each technology) are grouped together

(c) Banding based on a multiple-fraction ROC approach

(d) The frequency of banding settings will be linked to the EU ETS scheme - expectd to be 1 April 2013 and 1 April 2018

(e) Any changes will be announced 18 months prior to the introduction of such changes as specified in a review; banding reviews will occur every 3-5 years

2. Additional mechanism details

(a) Mechanism extended until 31 March 2037 (previously 2027)

(b) New projects eligible for 20 years support (up to the 2037 end date for the RO)

(c) Between 2014 and 2017 projects can choose between accrediing under the RO or proposed FIT CfD mechanisms

(d) Additional (new) or refurbished capacity will qualify for the full 20 year support up to 2037

3. Grandfathering

(a) Trigger point for grandfathering based on the date of planning consent

(b) Any reduction in the number of ROCs per MWh will only apply to future projects. Grandfathering extended to biomass conversion (from 1 April 2013), bioliquids (1 April 2013), CHP uplift (1 April 2013), energy crop uplift (1 April 2013), mid-range co-firing (1 April 2013) and high-range co-firing (1 April 2014)

(c) Standard co-firing, new biomass conversion and enhanced co-firing and microgeneration will not be grandfathered

(d) All technologies benefiting from grandfathering on 31 March 2017 will be grandfathered in the vintaged RO in 2017

4. Level of obligation

(a) The RO will be calculated by use of the headroom mechanism until 2027. The headroom level is 10 percent. Between 2027 and 2037 the price of a ROC will be fixed (a 'Fixed ROC')

5. Co-firing and biomass sustainability

(a) Co-firing cap removed (previously 12.5 percent) - but on-going consultation on cost control mechanism for co-firing and conversion bands

(b) Introducing a cap on new dedicated biomass plant accredited on or after 1 April 2013 without CHP - on-going consultation

(c) Capacity ceiling of 10 MWe for wood-fuelled stations with CHP under the ROS - on-going consultation

(c) Require power and CHP generators of 1 MWe capacity and above to meet new sustainability criteria to receive RO support for solid biomass and biogas from October 2013

(d) Sustainability criteria for solid biomass and biogas includes sustainable forest management criteria and tightening CO_2 emissions from new dedicated biomass and coal-plant converting to or biomass co-firing - on-going consultation

6. Funding for RO administration costs

(a) Administration costs will be taken from the buyout fund with the Government making up the difference in the event of a shortfall established in Section 33(3) are met. Differing from the factors for regular banding reviews (see above), these emergency triggers include: if another major support scheme with an impact on renewables starts, ends or is subject to significant changes; over-compliance of the obligation; other unforeseen event with a significant impact on the operation of the RO; significant changes in transmission/distribution charging for connecting/generating; demonstrated significant variation in net costs for a specific technology that changes the economic rationale for setting banding levels; and if a new technology with the ability for large-scale deployment arises.

The success of the banded mechanism is also strongly dependent on the correct inclusion of the appropriate RETs to the appropriate band during the process for setting the bands during future review periods. A number of criteria have been established in order help achieve this. These criteria include: taking into account full project costs (planning, construction, grid issues), income (wholesale price of electricity, avoided costs of the EU Emissions Trading Scheme (EU ETS), CCL, Landfill Tax), supporting the aim to maximise deployment in a sustainable manner, taking into account net neutrality, taking into account the cost-effectiveness and long-term potential of various RETs in delivering the set targets (for renewable generation) and wider strategic issues (for example. sustainability, carbon emission reductions).

One of the major effects of introducing technology banding to the RO was that the mechanism transitioned from a technology neutral to a differentiated support (subsidy) mechanism. As explained above, the levels of support for respective bands or more recently specific technologies can vary at the time of scheduled Banding Reviews (or emergency reviews) as set out in legislation. Alteration of the subsidy levels, however, could have a potentially negative impact on the position of companies that have made significant investments, particularly in the renewable electricity sector where most renewable electricity technologies have large upfront capital costs in contrast to more minimal operational and generational costs.[171] This could conflict with one of the aims

[171] This is not to say that the operational and generational costs (including maintenance costs) are insignificant *per se*. This will be true for those RETs with limited real deployment experience, particularly

of the RO, primarily "*… to allow generators to finance the fixed costs of their developments over the lifetime of the project's eligibility for RO support.*" (Burges Salmon, 2010: 1). Therefore the principle of grandfathering was introduced.[172] Grandfathering essentially means that the level of RO support that a generator receives is fixed or 'grandfathered' during the period that it is eligible for RO support from the point of accreditation. Importantly, the set level of support will not be reduced in any subsequent banding review. Grandfathering provides a guarantee of income to provide certainty and stability to the generator in order to secure third party debt and equity investment in the project. Sections 30 through to 32 of the 2009 Renewables Obligation Order established the legal basis of the principle of grandfathering (National Archives, 2009).[173]

Since the introduction of grandfathering in 2009, there have been a number of changes regarding which technologies are protected. In 2010, after consultation, the Government extended grandfathered RO support for Anaerobic Digestion, Energy from Waste, Dedicated Biomass (for non-fuel costs only) and Advanced Conversion Technologies. However, proposals to grandfather both bioliquids and energy crop uplift were rejected (DECC, 2010b, c). Although initially rejecting the proposal to grandfather dedicated biomass, the Scottish Government also decided after consultation to mirror

---

in the offshore (marine) environment or where they experience increasing component or deployment costs.

172 Grandfathering was first discussed in '*The Energy Challenge: Energy Review – A Report – July 2006*' document (DTI, 2006). Due to the aim of grandfathering (to provide a guarantee of income to provide stability to the generator and facilitate access to finance) and the fact that the idea was first published in the 2006 Energy Review, a transition arrangement was put in place: All generating stations (>50 kWe) except excluded RETs with full accreditation dates prior to 11 July 2006 would continue to receive 1 ROC/MWh although additional capacity would be treated depending on the date of accreditation. If receiving accreditation between 1 April 2009 and full accreditation by 31 March 2011, those RETs to be banded up would move up into new band whilst RETs to be banded down or in receipt of capital grants would continue to receive 1 ROC/MWh (unless the capital grants were returned). All other generating stations would move to the allocated band (up or down) except those with capital grants which could continue to receive 1 ROC/MWh or repay the grant in question (BERR, 2008).

173 Not all technologies and deployment scales were covered by grandfathering: Section 32(1) (ii) of the 2009 Renewables Obligation Order removed microgeneration technologies and biomass or waste generating stations (including fuels produced from biomass or waste by means of gasification, pyrolysis or anaerobic digestion) from grandfathering.

the UK proposals for the above biomass and waste RETs (Scottish Government, 2010a, b). Further changes to grandfathering were consulted on as part of the 2011 Banding Review at both the UK and Scottish level. The result of these parallel consultations was that the grandfathering policy was extended to include biomass conversion, mid-range co-firing bands, high-range co-firing band, CHP uplift, energy crops uplift for dedicated biomass and bioliquids except where utilised for co-firing. With the exception of high-range co-firing where grandfathering will come into effect on 1 April 2014, the extension of grandfathering to the remaining RETs is proposed to come into effect on 1 April 2013 (DECC, 2011a; DECC, 2012a; Scottish Government, 2011b; Scottish Government, 2012a).

A number of structural changes to the RO occurred directly after the 2009 reform as part of the '*Consultation on Renewable Electricity Financial Incentives*' (DECC, 2009b, c). These alterations to the mechanism came into effect on 1 April 2010. As initially set out in the 2008 pre-budget report '*Facing global challenges: Supporting people through difficult times*' the lifetime of the RO was extended by an extra 10 years to 2037 (HM Treasury, 2008).[174] The duration of a maximum support period for projects was also set at 20 years for those projects which achieve accreditation on or after 26 June 2008 up to the 2037 end date for the RO, including any additional (new) or refurbished or replaced capacity. Originally introduced with the 2009 reform of the RO, the headroom mechanism was also increased from 8 to 10 percent. With the RO set to be vintaged from 2017 onwards, the headroom mechanism will operate until 2027 whereupon a '*Fixed ROC*' will be established (see below). Headroom works by providing a set margin between predicted generation (supply of ROCs) and the Obligation level (demand of ROCs) and is designed to increase industry certainty in the RO and ensure that the value of ROCs will be protected in the event that increased deployment will in turn increase the risk of over-compliance due to weather or market conditions in a given year. Indeed, one of the aims of introducing headroom is to stabilise ROC prices by preventing

[174] The legal basis for the extension of the RO from 2027 to 2037 is article 17A(b) of the Renewables Obligation (Amendment) Order 2010 (for England and Wales) (National Archives, 2010a) and article 17A(b) of the Renewables Obligation (Scotland) Amendment Order 2010 (for Scotland) (National Archives, 2010b).

fluctuations in value as has occurred where the gap between deployment and the Obligation level has varied considerably.[175]

As was the case with the NFFO, the RO is an inherently complex mechanism for the government in terms of the administration of the mechanism by government and the independent energy regulator OFGEM. It also imposes requirements on developers/generators with regard to the level of knowledge and expertise necessary to operate within the mechanism. As can be seen from the discussion above concerning the evolution of the mechanism, particularly from the 2009 reform of the RO onwards, the complexity of the mechanism has increased. Subsidy mechanism complexity adds uncertainty and risk from the perspective of all potential investors, developers and operators of renewable generation plant. However, large companies are better able than smaller generators to manage this complexity with in-house expertise and/or the ability to pay for such expertise. Mechanism complexity itself could act as a barrier to new entrants, particularly at the small, independent and/or community level. There is also the issue of lobbying and rent-seeking due to mechanism complexity, with numerous groups (for example, trade bodies, environmental organisations and within government) arguing for and against specific RET options against the back-drop of subsidy levels in particular. Indeed, the issue of mechanism complexity as an internal failure is set to increase with the next wave of reforms.

The third wave of reforms to the Renewables Obligation centre around the ongoing process of electricity market reform in the UK.[176] The most recent Energy White Paper

---

[175] The 2009 reform also established the level of obligation at 20% in order to maintain RO levels above renewable generation up to 20%. This was subsequently removed in April 2010 as it would otherwise act as a barrier towards the 2020 RES-E target (around 30–35%) by placing an upper limit on the RO below what is actually required (Wood and Dow, 2011).

[176] The process of UK electricity market reform initially commenced with the reorientation of OFGEM's duties in the Energy Act 2008 (National Archives, 2008: 77) to include "*the need to contribute to the achievement of sustainable development.*" (Section 83(2)(c) of the Act). This led to the energy regulator's '*Project Discovery*' report from early 2009 to February 2010 (OFGEM, 2009; OFGEM, 2010). At the same time the 2009 Pre-Budget Report (HM Treasury, 2009: 123) published the UK Government's intention to "*… take forward work to ensure the electricity market framework can most effectively deliver a fair deal for the consumer and the low-carbon investment needed in the long term.*" This culminated in the previous UK Government publishing the '*Energy Market Assessment – March 2010*' (HM Treasury and DECC, 2010) document which built on OFGEM's analysis in conjunction with analysis from the recently convened

'*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011*' (DECC, 2011b) set out the proposals which include the introduction of a FIT CfD mechanism to ultimately replace the RO. It is not the intention of this thesis to evaluate the FIT CfD mechanism *per se*.[177] Although the EMR and FIT CfD proposals have not yet been fully designed and/or implemented, and as such are considered here as external failures (specifically under policy risk/uncertainty, see chapter eight) they will obviously have implications for the current mechanism: what will be the duration of the new contracts? Will the new subsidy level be comparable or different to the RO? This is of particular importance in the decision-making process of developers seeking to deploy new assets over the next few years. In addition, there are specific changes to the RO mechanism regarding the transition arrangements being put in place with the aim to protect existing as well as future investments under the RO and provide confidence to developers/investors in order to prevent a hiatus in renewable electricity investment whilst the new market arrangements are put in place (DECC, 2011b). This includes the acceleration of the RO Banding Review and the affect that has had on the setting of subsidy levels in addition to the changes proposed or already implemented under the recent RO review (see also below). Both will be critical given the deployment levels required to meet the 2020 sectoral RES-E target and the short timeframe imposed on industry.

The proposed transition arrangements fall broadly into two categories: (1) RO support to 31 March 2017 and (2) RO support from 1 April 2017 until 31 March 2037. In the

---

Committee on Climate Change's first progress report towards meeting the legally-binding UK Climate Change Act 2008 (CCC, 2008). The first '*Annual Energy Statement – 27 July 2010*' document (DECC, 2010e) stated the intention to issue the consultation document '*Electricity Market Reform Consultation Document – December 2010*' (DECC, 2010d). This process led to the 2011 Energy White Paper (see above).

[177] As of the end of 2012 (the data cut-off point of this thesis), the Government had not released specific details of the proposed CfD FIT mechanism. The 2011 White Paper set out the responses to the '*Electricity Market Reform Consultation Document*' and the rationale behind the government's choice of a CfD FIT (DECC, 2010b, d). Published in December 2011, the '*Technical Update*' (to the 2011 White Paper) focused on the institutional arrangements, the rationale for the Capacity Mechanism and the role of Final Investment Decisions during the transitional period. In addition, although the Government released the '*Energy Bill*' November 2012, this contained merely enabling legislation that permits the Secretary of State very broad powers to make regulations concerning the mechanism. In combination with the draft operational framework for the CfD FIT (also published in November 2012), both documents contain few critical details about both the mechanism and how it will operate.

period from the implementation of the FIT CfD (proposed for 2014) up to 2017, there will be a one-off choice of scheme for new RES-E projects, some limited grace periods and provisions for offshore wind phasing. The aim of grace periods is to ensure that projects that had invested on the expectation of receiving a certain ROC subsidy level could obtain this level upon commissioning.[178] In particular, such grace periods will only cover grid connection and radar installation issues, the reason being that these are specific construction risks out-with developer control and normal managed business risk (DECC, 2011f). Where generators feel there is a significant risk of missing the 31 March 2017 deadline due to factors out-with their control they will have the option of either choosing to accredit under the FIT CfD mechanism or to make use of a grace period. This will be a strictly controlled grace period for the reasons specified above and directed at those generators whose business case was based on RO support where accreditation was delayed beyond 31 March 2017. For those generators, the offer of grace periods will not affect the RO end date of 2037. The Government will put in place additional details, including evidence requirements for obtaining a grace period, closure to 2017.

Under the Renewables Obligation (Amendment) Order 2011 (ROO 2011) (National Archives, 2011) generators of offshore wind stations are also permitted to phase their RO support (called offshore wind phasing). Due to the substantial expected increase in size of offshore wind farms, particularly those proposed for Round 3 and Scottish Territorial Water (STW) projects and the typically long timescales for offshore projects, generators are permitted to register up to five phases of turbines over a maximum period of five years (with the first phase being at least 20 percent of total accredited capacity). Each phase, like all other RETs, is eligible for up to 20 years support up to the RO end date. However, with the RO being vintaged in 2017 and closed to new accreditations and additional capacity, generators will be eligible to either accept support under the FIT CfD for any remaining turbines (phases) or register the remaining unregistered turbines under the RO before 31 March 2017 in order to avoid

[178] Grace periods were originally introduced alongside technology banding in April 2009 for those RETs where support was decreased (DTI, 2007). Grace periods were also utilised in the recent banding review due to changes in subsidy level for certain RETs (DECC, 2012a).

receiving support split between the two mechanisms. As with the grace periods, the 20 year support period will not alter the RO end date.

Regarding the second category, the RO will be vintaged (it will no longer be open to accreditation for new stations resulting in a closed pool of capacity decreasing over time towards 2037), all RETs will be grandfathered at the rate set in 2017 (including those technologies not covered by grandfathering), the headroom mechanism will operate as normal until 2027 when a fixed ROC will be established until the end of the mechanism and provisions will be made for additional capacity (DECC, 2011f).

7.4 An evaluation of internal failures as potential constraints on renewable electricity deployment

In order to evaluate the potential performance of the Renewables Obligation, this section will analyse the internal failures of the mechanism on the deployment of renewable electricity technologies. As such, this section focuses on the way in which the UK Government financially promotes RES-E via the RO. This will include the wider implications of the design of the subsidy mechanism itself.

Currently the single largest government policy instrument in terms of cost, the Renewables Obligation is the main financial mechanism by which to subsidise renewables in order to support their deployment (National Audit Office [NAO], 2008). As the NAO report '*Government funding for developing renewable energy technologies*' (NAO, 2010: 20) states: "*The Renewables Obligation is intended to provide a long-term and stable framework to support investment in renewable electricity generating technologies.*"

Before evaluating the internal failures on deployment levels, it is worth looking briefly at the reasoning behind the main changes to the RO.[179] The main reason for reforming

[179] For a more detailed account regarding the 2009 RO reform process cf. Wood and Dow, 2010.

the mechanism in 2009 was that the UK Government recognised that if the RO was left unchanged, renewable deployment levels would be insufficient for meeting already established RES-E targets of 10.4 per cent by 2010 and 15.4 per cent by 2015 (Wood and Dow, 2011). According to modelling commissioned by the UK Government, the non-reformed RO would only attain 7.9 percent in 2010, 11.4 percent in 2015 and 12 percent in 2020 (OXERA, 2007). During this time, the EU was also moving towards more ambitious renewable energy targets which resulted in the EU 2020 targets (European Commission, 2007). The intention behind the reform was that

> "*It will provide the flexibility necessary to increase the deployment of renewable electricity generation in the years following 2009 and respond to the UK share of the EU 2020 target* [by over-coming the] *constraints on the availability and deployment of the cheaper forms of renewables which mean that, to meet the Government's long-term targets for renewable energy, we will need a significant contribution from renewable sources that are currently more expensive.*" (DTI, 2007: 3).

In order to meet the Government's long-term RES-E target for 2020, the primary way to achieve this was through the introduction of technology banding to increase the contribution from currently more expensive renewable energy technologies with the potential for mass deployment such as offshore wind by providing appropriate levels of support and certainty for future investment through the RO. An additional benefit perceived by banding the RO was that it would effectively side-step the external failures that have acted as constraints on cheaper RETs such as onshore wind, increase total renewables growth and mechanism efficiency in terms of renewable capacity with only moderate increases in costs to consumers (BERR, 2008).

7.4.1 Type of subsidy mechanism: The Renewables Obligation

One of the critical failures of the current subsidy mechanism is that by its design the Renewables Obligation has led to increased financial risk for RES-E generators (Wood, 2010; Wood and Dow, 2011). This is important because risk can be accorded a price. Under the RO, generators have two main sources of revenue: the sale of electricity and Renewable Obligation Certificates (ROCs), the latter capturing the 'renewable' (or environmental) value of the electricity.[180] A central problem is the considerable uncertainty surrounding the value of these revenue streams as they are traded on the market and thus are dependent on supply and demand.[181] The RO, then

> "*… (by design) passes regulatory risk to the private sector, which the private sector accordingly prices at a premium. This leads to leakage of the subsidy away from developers, as suppliers take a margin to deal with this risk and funding from financiers is therefore available on less favourable terms that it would otherwise be.*" (L.E.K. Consulting and the Carbon Trust, 2006: 2).

The added cost of the risk premium is not inconsequential: it could increase capital costs by up to 30 per cent (Johnston *et al*., 2007; L.E.K. Consulting and the Carbon Trust, 2006). This is particularly significant given the currently expensive nature of renewable electricity and the high level of upfront capital costs required in constructing the RETs. Reducing risk for generators can increase the number of projects that are financially viable. An additional effect is that the mitigation of such risk can also facilitate access for other types of developers and/or investors seeking to develop renewable generating assets.

In a liberalised market electricity prices are volatile and dependent on a multitude of factors that are often difficult to quantify and predict. As such,

> "*… market players pay high premiums for converting fluctuating market prices into fixed revenue streams. Hedging can be done through a contract that limits the price fluctuation to a certain price band or fixed-price contract. The corresponding hedging fees reduce the risk, but at the same time represent an additional cost.*" (Mitchell *et al*., 2006: 15).

On the other hand, ROC values are also volatile due to regulatory risk. This has been aggravated by the introduction of technology banding as the government can and has,

[180] The other revenues streams for a renewable generator are primarily the Climate Change Levy (CCL), a tax on the use of energy derived from fossil fuels introduced in April 2001 (with the exception of large-scale hydro power and some energy from waste plants) and the Recycled Buy-out Premium from the RO (HM Treasury, 2012; Komor, 2004).

[181] Both electricity prices and ROC values are volatile for a number of reasons (see below).

albeit under specified circumstances changed the subsidy level offered to renewable electricity technologies and even replace the subsidy mechanism itself. By increasing the cost of finance through the addition of a risk premium on capital, the RO effectively militates against small, independent and community-based projects in favour of larger, typically multi-national energy utilities. The latter companies can reduce the risk through their ability to obtain cheaper finance due to their balance sheets or by managing the risks in-house (if they own both generating assets and supply companies) (Wood and Dow, 2011). This also highlights the issue of ownership of power generation in the UK. Six large multi-national companies (the '*Big Six*') dominate both the electricity supply (99 per cent) and power station capacity (72 per cent) in the UK: E.On (Germany), EDF (France), Scottish power (Iberdrola, Spain), RWE npower (Germany) and Centrica and Scottish and Southern Energy (both British) (Friends of the Earth [FOE], 2011; Office for Gas and Electricity Markets [OFGEM], 2011b; Renewable Energy Association [REA], 2012a).

Despite the advantages for the energy utilities, concern has been mounting over a number of years that the RO would constrain access to the level of investment required and that particularly in the current economic and fiscal context the energy utilities would be either unable or unwilling to provide the financial investment required. This means that other sources of investment would also be required (such as pension funds) and that the financial risks need to be contained. These are the primary reason for the introduction of a FIT CfD mechanism under the EMR (see Chapter Seven, Section 7.5).

7.4.2 Subsidy Levels under the Renewables Obligation

The aim in setting subsidy levels is to maximise the deployment of renewable technologies whilst keeping wider policy aims in mind (see below). Prest (2012: 26) succinctly highlights the major areas of concern relating to this:

> "*If a* [subsidy level] *is set too high, then there will be a very strong market response and more support will be provided by electricity consumers than would have been necessary to incentivise significant levels of investment in generation capacity… generator profits will be more than a "reasonable" return on investment and the*

> *costs that must be recouped from electricity consumers will be "excessive"* [and could result in] *drastic counter reaction by government…* [This] *in the longer term will lead to stop go markets in which investor confidence is undermined and longer term growth is impeded. Alternatively, if the* [subsidy] *is set too low there will be insufficient response and inadequate or even negligible levels of investment will follow, market growth will be impeded… If investing in renewable generation is not made sufficiently profitable, investors will invest in other energy businesses* [or] *other opportunities outside the energy sector.*"

This means that setting the support level is a critical enabling factor. However, it is only one of a number of enabling factors (see below). The appropriate setting of the subsidy level also has to take into account the heterogeneous characteristics of renewable electricity technologies, with the various individual technologies at different stages of development and deployment (see Chapter four).

Section 7.2 examined the subsidy levels of the RO-eligible technologies for the period 2013-17 set out in the recent Banding Review (see in particular Table 7.1). An evaluation of the subsidy levels reveals a number of trends with regard to RES-E technology deployment: (1) subsidy levels are being driven to a large extent by cost issues; (2) the RO offers the greatest level of support for offshore wind, onshore wind and co-firing; (3) certain RETs such as geothermal and solar photovoltaic are being effectively side-lined; (4) subsidy levels do not fully consider the issues of scale, developer/owner type or additional characteristics of RETs; and (5) regulatory uncertainty is increasing due to the RO/FIT CfD transition and replacement and the subsidy level is not stable for a number of important RETs due to the number of consultations already in the pipeline despite the conclusion of the Banding Review only a few months ago.

The UK Government is attempting to balance controlling the costs of financially subsidising renewable energy through the RO while aiming to meet the renewable energy target.[182] The issue of costs is of course important: consumers are particularly

---

[182] This is also the case for the other subsidy mechanisms to promote not just RES-E deployment (the small-scale FIT) but for heat (the Renewable Heat Incentive) and transport fuels (the Renewable Transport Fuels Obligation).

sensitive to costs and renewable energy is typically more expensive than conventional forms of electricity generation (Komor, 2004; Mallon, 2007; Toke, 2011). Essentially this requires a trade-off in the particular approach adopted by the UK with regard to promoting RES-E deployment. This can be clearly seen by examining the aims for the RO mechanism set by the Government. As stated in the recent banding review that concluded in 2012, the aims of the RO are to ensure that (1) support levels under the RO will help meet the 2020 and interim RES-E sectoral targets; (2) support levels are suitable to deploy those RETs with the potential for mass deployment; (3) support levels are set as cost-effectively as possible to deliver good value for consumers; (4) ensure coordination with other DECC financial incentives schemes; (5) contribute to the effective delivery of wider energy and climate change targets to 2050 (including sectoral decarbonisation and security of supply); (6) to help provide long term energy security; and (7) to assist the UK renewables industry to become competitive in home and export markets, and in doing so, provide employment (DECC, 2011a; DECC, 2012a). As will be shown below, however, there are numerous points of conflict between the different aims of the RO. Over emphasising the reduction of costs, however, results in a number of implications for the deployment of a number of RES-E technologies. This will also have implications for the systemic interaction of the internal and external failures (see chapter nine).

But what are the reasons underlying the change in emphasis towards RO subsidy levels being driven primarily by issues of cost over other considerations? These include the aims of the Banding Review and the specific capping of the subsidy level for RETs (with the exception of marine renewables) by linking it to offshore wind. The consultation on the recent Banding Review makes this clear:

> "*In order to reduce excessive impacts on consumer bills and incentivise a sufficient level of deployment, we will need to reduce rents in the current banding levels, make use of the relatively cheap co-firing and conversion technologies, and drive down the costs of our marginal technology, offshore wind… By bringing down support for the most expensive technologies in line with the reducing costs of offshore wind, we ensure that we are not paying more than is necessary to get the deployment we need to meet our legally binding target.*" (DECC, 2011a: 9).

The main reason for the emphasis on cost, however, is the Treasury operated Levy Control Framework (LCF) which sets an overall cap on the amount of money that can be levied on consumer bills over the current Comprehensive Spending Review (CSR) period – 2011-15 with the aim to support renewable electricity generation cost effectively. The LCF covers the RO, the small-scale FIT and will be extended to cover the FIT CfD when it becomes operational.[183] In effect, it caps the money available for investment in renewables (and the money available for nuclear and CCS as well as renewables in the future as proposed for the FIT CfD) (HM Treasury, 2011). Introduced in the 2010 Spending Review, the LCF has set out the amount available to be spent over the period 2011-15 with a 20 per cent headroom mechanism of the total cap.

The amount levied on consumer bills should be controlled to avoid excessive costs and thus rents paid and thereby improve the efficiency of the RO and other support mechanisms. However, the LCF can have a direct impact on energy investment decisions. The Energy and Climate Change Committee (ECCC] report '*Draft Energy Bill: Pre-legislative Scrutiny: Volume I*' (ECCC, 2012a: 30) highlights a key problem with the LCF:

> "*The Framework says that if forecast or out-turn spend for any policy varies beyond a 20% "headroom" of the cap, DECC must urgently develop plans for bringing them back into line – or the Treasury may seek a financial contribution.*"

This creates a new risk for deployment. By capping the amount of spending in any given year, there is the risk that if the number of investments exceeds the LCF cap deployment could be delayed at a cost to investors/developers. Yet modelling for the UK Government by Redpoint shows that renewable deployment will accelerate towards 2020. This will be a particular problem for offshore wind given the scale of the projects now entering the development pipeline.[184] Such projects exhibit lumpy investment coming through the market with a lot of developers aiming at the same timeframe to

[183] The LCF also covers the Warm Home Discount scheme.

[184] In contrast to those offshore wind farms already operational which range in size (installed capacity) from 60 to 300 MW, new projects in development range from around 300 to 9,000 MW (Crown Estates, 2012a).

have those built and developed. This is exacerbated by the short timeframe available for meeting the sectoral target. In terms of installed capacity (size) and the capital required these projects are typically 10-20 times the size of previous offshore wind farms (see Chapter Seven for further details on offshore wind deployment). However, DECC is required to take the LCF into account in setting the subsidy levels in the Banding Review, as can be seen in the impact assessment published alongside the Government response to the banding review consultation:

> "*… bands were selected to ensure expected RO spend was less than the total RO budget for the four years of the Levy Control Framework (LCF) and that expected overspends in individual years did not exceed the 20% allowed flexibility on the overall LCF budget.*" (DECC, 2012k).

In other words, by controlling the amount available to be spent on renewables the LCF has arguably played a significant role in subsidy cuts under the RO. It is also a short-term framework. As such there is a lack of understanding not only about how the LCF will operate but also about what will happen after 2015 in terms of whether it will be extended or not. Importantly, it leaves open another issue. The UK has statutory renewable and climate change targets and "*the lights must be kept on*". This raises the issue of what is more important, the LCF or the targets. A four-year framework based on annual caps to manage an industry with 20-30 year investments horizons appears to be a mismatched solution to the issue of costs.

With the publication of the UK Renewable Energy Roadmap, the government effectively prioritised four technologies that are anticipated to "… *have either the greatest potential to help the UK meet the 2020 targets in a cost effective and sustainable way, or offer great potential for the decades that follow*" (DECC, 2011e: 6). These include wind power (onshore and offshore), marine energy (wave and tidal stream) and biomass electricity (biomass conversion and dedicated biomass). However, the Roadmap ignored a number of other RETs, most notably solar PV which deployed almost 1 GW in 2011 in addition to a number of biomass electricity technologies including anaerobic digestion, energy from waste, landfill gas and sewage gas. As of the end of 2011, these technologies accounted for 80 per cent of total installed capacity (onshore wind 37 per cent; offshore wind 15; and biomass electricity 28 per cent) and 82 per cent of total RES-E generation output (onshore wind 30 per cent; offshore wind 15; and biomass electricity 37 per cent). According to the Roadmap, these four RETs could contribute almost 90 per cent of the RES-E sectoral target by 2020 in terms of generation output.[185] But what will be the impact of the type of mechanism used to promote RES-E on RETs in the UK as well as the changes introduced in the Banding Review?

Although the 10 per cent reduction for onshore wind is evidence-based (to reflect long term cost movements), the Government has set this band (0.9 ROCs/MWh) for only one year, until 2014, pending the outcome of yet another review into the technology. This will have a number of repercussions not just for the technology but for the sector in general: the uncertainty could increase the financial risk on developers and lead to increases in the cost of capital (the risk premium) in addition to investors/developers waiting on the outcome of the new consultation. This could result in a hiatus in deployment. The political risk from the uncertainty over banding changes for the technology will also disproportionately impact on projects brought forward by small-scale developers.[186] This is because the subsidy reduction is based on the economics of larger-scale developments that are typically brought forward by larger companies such as the energy utilities in contrast to community or similar sized developers and the RO does not distinguish between the size of onshore wind projects with an installed capacity of 5 MW and above.[187] This ignores the evidence that there are differences

[185] However, when the Roadmap document was published in 2011, it stressed that the modelling "*ranges do not represent technology specific targets or the level of our ambition.*" (DECC, 2011e: 13, original emphasise (underline) retained). Since then, in the document '*Renewables Obligation Banding review 2013-17 – Public Consultation*', the Government appears to suggest that such deployment trajectories are now viewed at least within DECC as technology specific targets as set out in the individual technology chapters (DECC, 2012b).

[186] Small-scale in the context of the RO (as opposed to the small-scale FIT mechanism that supports projects with an installed capacity of between 50 kW to 5 MW) means projects with a deployed capacity greater than 5 MW but smaller than 50 MW – the meso-scale (Watson *et al*., 2010).

[187] The DECC-commissioned research '*Review of the generation costs and deployment potential of renewable electricity technologies in the UK*' (ARUP, 2011) provided the data on the current and expected cost trajectory of onshore wind (and all other RETs) underpinning the changes to bands in the Banding Review. However, rather than examine the economics of onshore wind farms at different scales (5-50 MW and +50 MW projects) to take into account differences between meso and larger-scale deployments, ARUP consolidated the data into one scale (+5 MW). In contrast to the RO and ROS, higher support is

between meso and larger-scale onshore wind farm costs, with the former more expensive on average (Mott MacDonald, 2011).[188] There are also likely to be the costs of community-scale participation (including lack of familiarity with the technology, policy, regulation and legislation). Indeed, the UK Renewables Roadmap states that the wide range of costs for onshore wind reflect, in part, the issue of scale (DECC, 2011e). In addition, there is concern that the subsidy cut could result in onshore wind development in peripheral and island areas being uneconomic despite higher average wind speeds due to the increased costs associated with the electricity network as well as supply chain and operation and maintenance issues.

For smaller projects, in particular community-based or those that fit within the so-called 'meso-scale' the reduction in revenue in conjunction with increased regulatory risks including revenue uncertainty will make it more difficult and expensive to secure finance. In other words, subsidy reduction will fall disproportionately on community-based and meso-scale projects. A result of this is that a number of projects are likely to become unviable. This is despite the benefits that can accrue from this scale of deployment: reduced environmental impacts (locally-sourced supplies, reduced transportation), building supply chains, employment and industry growth at the local level particularly in rural areas in addition to mitigating planning and public acceptance and other barriers (see chapter eight, section 8.3) (DECC, 2012c). In addition, despite the specific aim of the reduction to deter poorly-sited projects, the subsidy cut will only serve to increase pressure on all developers to locate onshore wind farms in the areas of highest resource availability which has historically and continues to aggravate a number of external failures that have significantly constrained deployment in the UK (see chapter eight).

---

available for small-scale onshore wind under the Northern Ireland Renewables Obligation (NIRO). There are 3 bands for onshore wind: 250kW or below; >250kW to 5MW; and >5MW (Department of Enterprise Trade and Investment, 2012).

[188] Central costs for large and small unit wind farms are £1,350/kW and £1,450/kW, respectively (Mott MacDonald, 2011: 37).

In effect, offshore wind has been effectively banded up although future subsidy levels will also decrease during the period up to 2017 (by 10 per cent from 2015/16). In conjunction with the planned reduction in subsidy, the Government also made it clear that "*... the cost of electricity from offshore wind would have to fall significantly by 2020 if we are to fulfil our ambitions, amounting to some 18GW of capacity*" (DECC, 2012g: 3). This led to the establishment of the Offshore Wind Cost Reduction Task Force (CRTF) with the aim to reduce costs to £100/MWh by 2020.[189] There is also currently around 45 GW of offshore wind in the development pipeline (in construction, with planning consent, in planning pre-consent or development) (Crown Estates, 2012a, b). Offshore wind, then, is also expected to have a significant impact on RES-E deployment post-2020. The important question is: What happens if offshore wind fails to achieve these cuts in the relevant timeframe? This is particularly relevant for a number of reasons. Contrary to previous expectations the cost of offshore wind development have escalated from the mid-2000s onwards rather than decreasing.[190] Critically

> "*... the trend downwards [in costs] is not likely to mirror the recent precipitous trend upwards. The period to the mid 2020s is most likely to see gradual reductions. And these can only be delivered if a range of key drivers can be aligned.*" (United Kingdom Energy Research Council [UKERC], 2010: 97).[191]

The Crown Estates report '*Offshore Wind Cost Reduction: Pathways Study*' estimated that levelised costs would either increase (£150/MWh under the rapid progression model)

---

[189] Currently the levelised cost (or lifetime cost of a project per unit of energy generated) of offshore wind is estimated at £149-191/MWh (DECC, 2011e).

[190] Between the late 1990s and mid-2000s the consensus was that offshore wind costs would fall significantly lower in the medium to long term. This premature conclusion was justified on the costs of the early deployment of the first two rounds of the Crown Estate's Offshore Wind Leasing Programme (Rounds 1 and 2), contemporary deployment costs from other countries experiences with offshore wind and the historical trends evidenced from onshore wind. Instead, offshore wind capital costs had doubled between 2003 and 2008 whilst estimates of levelised energy costs had increased 50 % between 2006 and 2009 (Ernst & Young, 2009; UKERC, 2010).

[191] Concern over increasing costs for offshore wind has been repeated by DECC, the CCC and the Crown Estates in various publications (Committee on Climate Change [CCC], 2012; Crown Estates, 2012c; DECC, 2012g). The Crown Estate is a property portfolio owned by the Crown governed by an Act of Parliament (Crown Estate Act 1961) and managed by an independent organisation headed by the Crown Estate Commissioners. One of the largest property owners in the UK, it owns approximately 55 per cent of the UK's foreshore and virtually all of the UK's seabed from mean low water to the 12 nautical mile (or 2 km) limit. Surplus revenue is paid annually to HM treasury (Crown Estate, 2012d).

or remain relatively constant to 2014 before falling to between £115 to £134/MWh by 2017 and £89 to £115/MWh by 2020 (Crown Estates, 2012c). This is dependent on the resolution of a number of key drivers that increase costs for offshore wind.

These drivers include: gaps in the delivery schedule over the next few years; supply chain constraints and uncertainty; construction and technological risks; regulatory and financial incentive risks (RO/FIT CfD transition/replacement); planning issues; electricity transmission issues; component and material costs (steel, copper, turbines, etc); exchange rates (Crown Estates, 2012c; DECC, 2012g; UKERC, 2010; Wood and Dow, 2011). Not all of these drivers are exclusive to offshore wind. Indeed, a number of these issues are highly relevant to the potential performance of the UK RES-E deployment programme (see Chapter Seven). Costs are also expected to be higher for the later Crown Estates Rounds 3, Scottish Territorial Waters, Northern Ireland Renewable Energy Programme and Round 2.5 due to the difficulties associated with deploying the technology in deeper waters farther from shore (in contrast to the earlier rounds) (UKERC, 2010). Despite this, the UK Government has decided that there is not a sufficient case to provide different levels of support based upon these locational considerations due to the higher resource availability (DECC, 2012a).

Linking the subsidy levels of more expensive RETs to offshore wind with the exception of marine renewables fails to take into account the different technological level of other non-offshore wind technologies. In addition, it does not take into account the benefits of scale or resource potential or additional beneficial characteristics such as providing renewable base-load capabilities, storage and flexibility of operation of certain RETs. Examples of such technologies include solar photovoltaic, anaerobic digestion and geothermal power. In particular, this will affect the latter technology. With a resource potential of 9.5 GW of installed capacity of a renewable base-load technology which could supply around 35 TWh/year, geothermal is currently at a similar stage of development to wave and tidal stream.[192] In contrast to these two technologies,

[192] 9.5 GW is the equivalent of around 9 nuclear power stations. In addition, to power generation, a report published by Sinclair Knight Merz (SKM) found that the potential heat from geothermal could equal 100 GW (SKM, 2012). By 2030 the global industry is expected to be worth around £30 billion (REA, 2012b).

however, subsidy support for geothermal will decline in line with offshore wind. This is despite the fact that although geothermal has been offered 2 ROCs/MWh since 2009, no deployment has occurred as of yet.[193] In addition, it does not take into account additional beneficial characteristics such as flexibility of operation which is important in balancing the electricity system. Anaerobic digestion could also act as a base-load RET with a high level of flexibility of operation in addition to other environmental benefits including the reduction of landfill waste, providing bio-fertiliser as a waste product, conversion into biofuels, put into the gas grid and heat production(DECC and the Department for Environment, Food and Rural Affairs [DEFRA], 2011). However, although the technology is at an immature technological stage and there are varying costs depending on different types and sizes of plant (scale), the RO '*one size fits all*' approach (also in evidence for onshore wind) will constrain the deployment of this technology despite such factors greatly varying the costs (DECC, 2012a). This means that the additional benefits of meso or community-scale ownership are also lost. Although a mature technology, hydro power is also another technology that could contribute primarily at the meso or community scale, and has the benefit of providing base-load and storable renewable electricity generation. There is a danger that the cut in subsidy from 1 to 0.7 ROCs/MWh could put in jeopardy around 300 MW of proposed capacity of 5 MW sites or above despite the benefits of this technology, including storage and frequency responses.[194] These are key attributes as the UK increases the deployment of intermittent renewables.

In 2011, almost 1 GW of solar photovoltaic was deployed under the small-scale FIT mechanism. This was the single largest increase in installed capacity for that year, and

---

[193] The UK Government has provided funding of around £9.5 million to support the first two demonstration projects in Cornwall (Redruth and at the Eden Project) (DECC, 2012a). Interestingly, the UK and Iceland signed a Memorandum of Understanding that will explore the possibility of developing an electricity interconnector between the two countries to allow the UK to utilise Iceland's geothermal power (DECC, 2012h).

[194] Scotland has the largest potential resource availability of new hydro power in the UK and has retained the current subsidy level (1 ROC/MWh) (Scottish Government, 2012a).

the first time onshore wind failed to lead in terms of deployment.[195] In particular, solar PV has a number of benefits: it has a substantial resource base in the UK of up to 140 TWh/year; strong growth in employment (estimates of around 25,000 with 3,800 PV installers accredited to the Microgeneration Certificate Scheme in 2011) (Parliamentary Office of Science and technology [POST], 2012); in the top ten high growth sub sectors in 2010 (Ernst & Young, 2011); can be deployed on-grid as well as off-grid; plays an important role in decarbonising the building stock; is suited to community-scale schemes (including housing associations and local authorities) (Energy and Climate Change Committee [ECCC], 2011a); and is a route for people to generate their own renewable electricity and be involved in the deployment of renewable energy.

Deployment has been driven almost completely by the FIT to date. However, given the importance of this RET to overall renewable energy policy aims (in addition to the benefits listed above) there is the potential for large-scale (RO supported) solar PV. Under the RO, however, solar PV subsidy levels have also been linked to offshore wind, resulting in a reduction from 2 ROCs/MWh (2013/15) to 1.9 (2015/16) and 1.8 (2016/17) (DECC, 2012a). However, despite the Banding Review only concluding a few months ago, a new consultation has been released indicating further reductions in RO-eligible solar PV (DECC, 2012j). Proposals include resurrecting the removal of sub-5 MW installations from the RO and further subsidy reductions for +5 MW installations: from the current 2 ROCs/MWh to 1.5 ROCs/MWh in 2013/14, 1.3 ROCs in 2014/15, 1.1 ROCs in 2015/16 and 0.9 ROCs in 2016/17. These cuts mirror the scale of those that occurred for sub-5 MW installations supported by the FIT. Both are driven in large part by the introduction of the LCF in 2010.

Such proposals act to increase uncertainty for solar PV developers due in part to the earlier cuts under the small-scale FIT mechanism[196] and the number of consultations

[195] Onshore wind came third with +614 MW and offshore wind fourth (+446 MW). Plant biomass was second with 850 MW. However, growth in solar PV has slowed dramatically due to the cut in FIT subsidy levels and the mishandling of the cuts by DECC (Business Green, 2011). In addition, further reductions are planned under the FIT (DECC, 2012i).

[196] Under the FIT, solar PV has faced repeated consultations (February 2011, October 2011, February 2012) and evidenced significant reductions in subsidy (tariff) level at all scales within the scheme. The

that have focused on solar PV for the FIT and RO. As with other RETs already discussed previously, community solar power schemes face specific problems because of the Government's proposals:

> "*… they depend more acutely on the tariff income to finance the installations; they need longer to organise their projects; and they will be hit by even lower tariffs for 'aggregators'. Community schemes typically take longer to complete because securing the necessary funding and planning permission can take time. Many are run by volunteers and so they can take longer to organise.*" (ECCC, 2011a: 14).

Although this report looked primarily at FIT solar PV installations, the specific problems listed for sub-5 MW solar PV are the same for a number of RETs including hydro, onshore wind, anaerobic digestion and solar PV at the FIT and meso-scale deployment levels. Community-scale projects also require a sufficient financial return in addition to transparency and stability in subsidy levels in order to borrow capital at rates not prohibitive to development. Yet community-scale projects will typically find it harder to access capital as cheaply as larger companies would. The approach to solar PV (and a number of other RETs) is perplexing given the additional benefits of the technology and recent government-led aspirations for over 20 GW from the technology by 2020 (DECC, 2012f). It also assumes that the cost reductions are indicative of a natural and sustainable fall and that the costs for sub-5 MW and +5 MW installations (and all the tariff bands/project sizes in-between) are the same.[197] Although there are currently no

---

Government has been accused of mishandling the cuts (setting the new tariff levels prior to the end of the first consultation, retroactively cutting subsidies) with a resultant impact on the fledgling solar PV industry: "*DECC's own analysis shows the market could be cut by over 90%. The scale of uncertainty leaves the whole sector edging towards the cliff edge.*" (Ares *et al*., 2012: 14). Indeed, the High Court ruled on 21 December 2011 that the setting the cut off date for the new tariffs two weeks before the end of the consultation was illegal. Both the Court of Appeal and the Supreme Court upheld the decision (BALILI, 2012). For a full account of the reviews and reductions in subsidy under the FIT, see also the Inquiry into solar power feed-in tariffs (ECCC, 2011a, b; 2011c).

[197] There is some evidence that the costs of solar PV technologies will not maintain similar cost reductions due to the on-going trade dispute regarding solar 'dumping' (the selling of panels for substantially less than the cost of production) by China. On the 6 September 2012, the European Commission launched such an investigation into imports of solar panels and key components (solar cells, solar wafers) originating in China. Although the investigation is scheduled to take 15 months, it is possible according to trade defence rules to impose provisional anti-dumping duties (the imposition of import tariffs on Chinese solar PV equipment) within 9 months provided there is sufficient prima facie evidence of dumping which the EC has agreed exists (Europa, 2012). In a separate dispute, the US imposed import tariffs of up to 250% on Chinese exports (Mondaq, 2012). This is significant for solar PV in the UK and

+5 MW RO-eligible projects deployed in the UK, the impact assessment accompanying the new consultation shows that further reductions would cut deployment growth from 720 MW to 0-80 MW by 2016/17 (DECC, 2012k).

There are a number of reasons behind the decoupling of marine renewables from the offshore wind cap and the significantly higher subsidy level (5 ROCs/MWh). Although it is largely a symbolic gesture given the unlikelihood of any significant deployment for these technologies in the short-term it acts both as encouragement and an incentive to attract investors to the UK. The UK is currently a world-leader in wave and tidal stream technologies and the global focal point for their development. This can be seen by the concentration of R&D, testing and the Crown Estate leasing programmes. It is also relevant that this is heavily focused in Scotland which has offered a higher level of subsidy (ROCs and MSOs) for the longest period of time. The aim is to promote these technologies which have the potential to deploy at large-scale in the long-term (post-2020) as well as benefits from domestic/export market growth and employment (DECC, 2012a; L.E.K. Consulting and the Carbon trust, 2006).

It is also necessary to enable wave and tidal stream energy to progress from the prototype testing stage to the deployment of single or small arrays in the marine environment in order to increase commercial and real-world experience and learning. As Wood (2010: 66) states:

> "*Only by achieving this can wave and tidal power play a meaningful role with regard to the set targets for renewable energy deployment… for this to occur, there are five major challenges required to be overcome: financial support, planning, grid, infrastructure (including supply chain) and policy uncertainty.*"

Marine RETs are classed as an emergent technology. As such, they are a high-cost, high risk technology option (Forum for Renewable Energy Development [FRED], 2009). This

beyond for two reasons: China is the world's largest producer of solar panels (61% of global production) and the EU accounts for approximately 80% of Chinese export sales (PVTech, 2012; Renewable Energy Policy Network for the 21st Century [REN21], 2012). Secondly, it can be argued that the proposed subsidy cuts in the UK are based on recent cost reductions in part due to the 'dumping' of Chinese equipment in the EU/UK market. Import tariffs can only increase the costs at a time when the UK Government is seeking to make deeper cuts for what are primarily budgetary reasons.

is true even in comparison to offshore wind which has significantly de-risked in terms of the market and technological level in recent years (Wood, 2010). The substantial RO support is important but only once generation begins and subsidies accumulate over time. One of the critical factors required to drive deployment to the deployment stage will be the provision of public funding from strategic funding bodies (Wood, 2010). Although the situation is improving the funding landscape has been described as overly complex with the potential for duplication and overlap between the schemes (at the EU, UK and devolved administration level), inefficiencies associated with projects having to apply to multiple schemes and the administrative costs associated (ECCC, 2012a; Wood, 2010).[198] Regarding revenue support, the increase in subsidy at the UK level will not occur until 2012/13 and will only run for five years. This is in contrast to Scotland where there has been an enhanced subsidy level for these technologies in operation since 2007.[199] In addition, the 30 MW cap appears arbitrary, determined as it is on cost issues driven by the LCF (DECC, 2012a).

Perhaps a greater risk to the marine renewables sector is the closure of the RO in 2017 and the uncertainty regarding the proposed FIT CfD mechanism. There is a lack of continuity or long-term view concerning what happens beyond the deployment of the first (sub-30 MW) arrays (ECCC, 2012b). There is also the danger that if the LCF is extended beyond the current Spending Review, the higher costs of marine RETs will be constrained due to budgetary requirements. This position is not purely unique to marine RETs. All other renewable electricity technologies are currently faced with the same problem: the industry urgently needs clarity about the level of support it can expect to receive beyond 2017. It is all very well establishing the transition arrangements for the RO/FIT CfD switch, but it is difficult to take the position that

---

[198] The UK government is also having to catch up with efforts in Scotland where there has been a number of funding initiatives to progress marine RETs from proof of concept RD&D to commercial deployment for a number of years (Wood, 2010).

[199] Prior to the introduction of technology banding in 2009, the Scottish Government established the Marine Supply Obligation (MSO) that ran from 2007 until 2009 (Scottish Government, 2008). In 2009, wave and tidal stream received 5 and 3 ROCs/MWh, respectively (comparable to the MSO support levels). In contrast to wave power, tidal stream will only increase to the same subsidy level in 2012/13 (Scottish Government, 2012a).

developers/investors will not wait and see what will happen regarding the new mechanism in terms of the details and possibly even the operation of the mechanism. A likely outcome would be a hiatus in deployment with subsequent implications for other policy aims, including the development of supply chains, industry and employment. Although this is the case with other renewable electricity technologies, marine RETs will be in the somewhat unique position of reaching the stage required for more substantial deployment.

The situation for biomass RETs is more complex than before due to the changes that have been introduced for these technologies under the Banding review. Overall, in line with the UK Government's aims to incentivise RES-E deployment whilst reducing costs, the UK Government is seeking to increase deployment from those technologies with the capacity to deploy significantly within a short timeframe in a cost-effective way (DECC, 2012a). These technologies include dedicated biomass and sewage gas (previous subsidy level retained), biomass conversion (a new band although subsidy level has fallen by a third) and co-firing. Support for co-firing has been differentiated depending on the percentage of biomass (or bio-liquids) combusted with fossil fuels. In effect, support for co-firing has either been retained (with temporal decreases in subsidy between 2013/16 for standard co-firing) or increased for those bands with the highest proportion of biomass content (enhanced co-firing). Both standard and enhanced co-firing with CHP and where energy crops are utilised have also had an increase in subsidy level, reflecting the benefits of heat production and using feedstock specifically used for biomass to build up the supply chain. Importantly, the cap on co-firing has been removed. With the exception of dedicated biomass, these biomass RETs represent the most cost-effective potential: co-firing of biomass is one of the cheapest and quickest ways to decarbonise electricity by switching from coal to biomass (DECC, 2012a). In contrast, eligibility for the dedicated biomass band requires new build power plants. This is the reason why the subsidy level has been retained at the previous level as analysis showed that this would only bring forward small-scale dedicated biomass plants below 50 MW (ARUP, 2011).

The UK Government anticipates that these biomass technologies will make a significant contribution towards the 2020 RES-E sectoral target. This can be seen by current and projected levels of biomass electricity in the UK. As set out in the UK Renewable Roadmap, biomass electricity is anticipated to deploy approximately 6 GW of installed capacity by 2020 (DECC, 2011e). At the end of 2011, the UK has around 2.5 GW of installed capacity of all biomass technologies already in operation. In addition, there is enough capacity in the development pipeline if historic planning approval rates are taken into account to meet the target which could provide between 32 and 50 TWh/year (equivalent to 20-44 per cent of the RES-E sectoral target).[200] The significance of this is that the focus on promoting more deployment of biomass electricity could result in increased deployment above the 6 GW target if future planning rates are equal to the historic failure rate. Another factor is the removal of the co-firing cap. In combination with the increased subsidy levels particularly for enhanced co-firing, this is expected to increase deployment significantly. However, the imposition of supplier and cost caps on the major biomass electricity bands and the reduction in the volume of coal capacity due to environmental legislation results in a fundamental constraint on co-firing post-2015. However, there are a number of problems with the promotion of biomass electricity in general and these RETs in particular. These include: sustainability issues and the proposed changes to a number of biomass bands, including proposals to introduce supplier and cost caps as well as band closures.

While biomass energy is eligible for multiple public subsidies, including under the RO,[201] there are substantial concerns over both the sustainability of biomass (in terms of greenhouse gas emissions and rate of resource renewal) and the inadequacy of current safeguards to ensure the fuel source is sustainable (Client Earth, 2012). As chapter four (section 4.2) showed, there are valid arguments that a number of biomass fuels and technologies produce significant greenhouse gas emissions. Although there is a high level of variation between technologies/fuel types used, some exhibit higher GHG

[200] Generation output for 2020 also includes current generation in 2011.

[201] Biomass energy also benefits from an exemption from the European Union Emissions Trading Scheme (Client Earth, 2012).

emission levels than low carbon technologies and there is also considerable overlap with natural gas. Regarding GHG emissions, the CCC has stated that biomass should not play a role in power generation without CCS (CCC, 2011).[202] In contrast to the UK position, the Scottish Government is in agreement with the CCC recommendations (Scottish Government, 2012a). There is also the issue of resource renewal and this is intrinsic to the debate of what constitutes a source of renewable energy. There is a growing awareness that biomass feedstock cannot support the current or required rates needed for the projected growth in energy generated from biomass (whether for power, heat or transport) (CCC, 2011). Although this is particularly the case for domestic biomass resources, there are also severe constraints on the import capabilities at the EU and global resource availability (Client Earth, 2012; Mantau *et al*., 2010). However, the UK Government has not differentiated support on whether or not the biomass is sourced domestically or internationally. Although there would be difficulties in this approach, they would also mitigate some of the problems of resource sustainability and contribute towards the development of a UK supply chain with resultant sustainability benefits (locally-sourced). Relying on an increased level of deployment for biomass will only exacerbate these problems.

The UK Government is aware of these concerns, particularly the issue of sustainability of the biomass resource base. This has led, however, to a plethora of changes and a further round of consultations being placed on biomass RETs due to the need not only to increase but also, critically, to control the level of deployment/output from these technologies whilst remaining within the LCF cap. This has led to claims that the Banding Review has resulted in the biomass power sector becoming a ‘minefield’ for investors/developers due to the added complexity (National Non-Food Crops Centre [NNFCC], 2012). Such changes include the closure of technology bands as early as 1 April 2015 for a number of biomass RETs. In addition, there are forth-coming consultations on proposals to change the level of support for standard co-firing in 2013/14 and 2014/15, to introduce cost control mechanisms under the RO for the co-

[202] There are also other environmental, economic and social issues regarding the use of biomass for electricity production (see chapter four).

firing and biomass conversion bands and to introduce a supplier cap on dedicated biomass to limit the amount of new build supported under the RO.[203] This means that a number of biomass technologies that are anticipated to contribute significantly to future RES-E deployment and generation face ongoing uncertainty which can only have a negative impact on industry confidence and deployment rates. This will also have additional implications for the development of a biomass supply chain given the uncertainty in subsidy levels and the supplier and cost mechanisms, in part due to the over-riding requirements of the LCF and the early closure of a number of bands. Apart from job growth and facilitating deployment, this could also potentially improve the sustainability of the biomass feedstock.

[203] The exact changes and forth-coming consultations include: the closure of 7 biomass technology bands (open landfill gas on 31 March 2013, biomass conversion with CHP, dedicated biomass with CHP, co-firing standard with CHP, enhanced co-firing with CHP, standard co-firing of energy crops with and without CHP (from 1 April 2015); 8 new consultations (for dedicated biomass, both standard co-firing bands, the high-range enhanced co-firing band, co-firing of energy crops with and without CHP and sewage gas). The consultations on whether or not to impose a supplier or cost control mechanisms is for dedicated biomass and high-range enhanced co-firing and biomass conversion respectively (DECC, 2012a).

References

Ares, E., Hawkins, O. and Bolton, P. 2012. Feed-in Tariffs: Solar Review: Standard Note: SN/SC/6112 – 5 April 2012. House of Commons Library

Arup, 2011. Review of the generation costs and deployment potential of renewable electricity technologies in the UK: Study report REP001 Final – Updated October 2011 for the Department of Energy and Climate Change [online] Available from http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renew_obs/1834-review-costs-potential-renewable-tech.pdf

BAILII, 2012. Secretary of State for Energy and Climate Change –and- Friends of the Earth and Others – 25/01/2012: Neutral Citation Number: [2012] EWCA Civ 28 – Case No: C1/2012/0023 [online] Available from http://www.bailii.org/cgi-bin/markup.cgi?doc=/ew/cases/EWCA/Civ/2012/28.html&query=solar&method=boolean

Burges Salmon, 2010. Renewables Obligation: a summary of the Grandfathering Consultation – June 2010 [online] Available from http://www.burges-salmon.com/Practices/environment_and_health_and_safety/renewables/Publications/Renewables_Obligation_a_summary_of_Grandfathering_Consultation.pdf

Business Green, 2011. Updated: High Court Judge rules solar consultation legally flawed: Court rules in favour of solar firms, throwing government feed-in tariff plans into chaos – 21 December 2011 [online] Available from http://www.businessgreen.com/bg/news/2134194/breaking-court-judge-rules-solar-consultation-unlawful

Client Earth, 2012. Further comments on the Government's proposals for support for solid biomass power under the Renewables Obligation: London – 12 January 2012 [online] Available from http://www.clientearth.org/reports/consultation-on-renewables-obligation-banding-review-and-renewables-obligation-order-2012-further-comments.pdf

Committee on Climate Change [CCC], 2011. Bioenergy Review – December 2011 [online] Available from http://downloads.theccc.org.uk.s3.amazonaws.com/Bioenergy/1463%20CCC_Bioenergy%20review_bookmarked_1.pdf

Committee on Climate Change [CCC], 2012. Meeting Carbon Budgets – 2012 Progress Report to Parliament – June 2012 [online] Available from http://hmccc.s3.amazonaws.com/2012%20Progress/CCC_Progress%20Rep%202012_bookmarked_singles_1.pdf

Crown Estate, 2012a. The Crown Estate: project details for offshore wind [online] Available from http://www.thecrownestate.co.uk/energy/offshore-wind-energy/our-portfolio/project-details/

Crown Estate, 2012b. UK Offshore Wind Report 2012 [online] Available from http://www.thecrownestate.co.uk/media/297872/UK%20offshore%20wind%20report%202012.pdf

Crown Estate, 2012c. Offshore Wind Cost Reduction: Pathways Study [online] Available from http://www.thecrownestate.co.uk/energy/offshore-wind-energy/working-with-us/strategic-workstreams/cost-reduction-study/

Department of Business, Enterprise and Regulatory Reform (BERR), 2008. Renewables Obligation Consultation: Government Response (URN 08/531) January 2008 [online] Available from http://www.berr.gov.uk/files/file43545.pdf

Department of Energy and Climate Change [DECC], 2009a. Smarter Grids: The Opportunity [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/futureelectricitynetworks/1_20091203163757_e_@@_smartergridsopportunity.pdf

Department of Energy and Climate Change [DECC], 2009b. Consultation on Renewable Electricity Financial Incentives 2009 [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20090722165845_e_@@_ConsultationonRenewableElectricityFinancialIncentives2009.pdf

Department of Energy and Climate Change [DECC], 2009c. Government Response to the 2009 Consultation on the Renewables Obligation [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20091214132326_e_@@_GovernmentResponse2009ConsultationontheRenewablesObligation.pdf

Department of Energy and Climate Change [DECC], 2010a. Feed-in Tariffs (FITS): What Is FITS? [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/feedin_tariff/feedin_tariff.aspx

Department of Energy and Climate Change [DECC], 2010b. Consultation on the grandfathering policy of support for Dedicated Biomass, Anaerobic Digestion and Energy from Waste under the Renewables Obligation – March 2010 [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/RHI/1_20100331161514_e_@@_GrandfatheringSupport.pdf

Department of Energy and Climate Change [DECC], 2010c. Government Response to the Consultation on the Grandfathering Policy of Support for Dedicated Biomass, Anaerobic Digestion and Energy from Waste Under the Renewables Obligation – 27 July 2010 [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/RHI/245-government-response.pdf

Department of Energy and Climate Change [DECC], 2010d. Electricity Market Reform: Consultation Document – December 2010 [online] Available from http://www.decc.gov.uk/assets/decc/consultations/emr/1041-electricity-market-reform-condoc.pdf

Department of Energy and Climate Change [DECC], 2010e. Annual Energy Statement: DECC Departmental Memorandum – 27 July 2010 [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/237-annual-energy-statement-2010.pdf

Department of Energy and Climate Change [DECC], 2011a. Consultation on proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: URN 11D/876: October 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Department of Energy and Climate Change [DECC], 2011b. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change [DECC], 2011c. Networks Strategy and Regulation: Developing a UK Smart Grid [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/network/strategy/strategy.aspx

Department of Energy and Climate Change (DECC), 2011d. Energy Trends – December 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/3917-trends-dec-2011.pdf

Department of Energy and Climate Change (DECC), 2011e. UK Renewable Energy Roadmap – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change (DECC), 2011f. Annexes to the White Paper: Annex D – Renewables Obligation transition [online] Available from http://www.decc.gov.uk/assets/decc/11/policy-legislation/EMR/2173-planning-electric-future-white-paper.pdf

Department of Energy and Climate Change [DECC], 2012a. Government response to the consultation on the proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: July 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Department of Energy and Climate Change [DECC], 2012b. Biomass Electricity & Combined Heat & Power plants – ensuring sustainability and affordability: Consultation on proposals to enhance the sustainability criteria and to ensure affordability for the use of biomass feedstocks under the renewables obligation (RO) – URN: 12D/015 – 7 September 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/6339-consultation-on-biomass-electricity--combined-hea.pdf

Department of Energy and Climate Change [DECC], 2012c. Onshore Wind – Call for Evidence: Part A – Community Engagement and Benefits – 20 September 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/consultation/wind/6437-onshore-wind-call-for-evidence-document-part-a-com.pdf

Department of Energy and Climate Change [DECC], 2012d. UK Bioenergy Strategy – April 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/bio-energy/5142-bioenergy-strategy-.pdf

Department of Energy and Climate Change [DECC], 2012e. Planning our electric future: technical update – December 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/energy-markets/3884-planning-electric-future-technical-update.pdf

Department of Energy and Climate Change [DECC], 2012f. Greg Barker confirms way forward for small scale renewable electricity under government scheme: Press Notice: 12/114 – 2 October 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/news/pn12_114/pn12_114.aspx

Department of Energy and Climate Change [DECC], 2012g. Offshore Wind Cost Reduction Task Force Report – June 2012 [online] Available from http://www.decc.gov.uk/publications/basket.aspx?filetype=4&filepath=11%2fmeeting-energy-demand%2fwind%2f5584-offshore-wind-cost-reduction-task-force-report.pdf&minwidth=true#basket

Department of Energy and Climate Change [DECC], 2012h. UK and Iceland Sign Energy Agreement: Press Notice: 12/071 – 30 May 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/news/pn12_071/pn12_071.aspx

Department of Energy and Climate Change [DECC], 2012i. FITS review: Update: 16 October 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/fits_review/fits_review.aspx

Department of Energy and Climate Change [DECC], 2012j. Consultation on proposals for the levels of banded support for solar PV under the Renewables Obligation for the period 1 April 2013 to 31 March 2017: Reference Number: 12D/318 [online] Available from
http://www.decc.gov.uk/en/content/cms/consultations/ro_solarpv/ro_solarpv.aspx

Department of Energy and Climate Change [DECC], 2012k. Impact Assessment: Consultation on proposals for the levels of banded support for solar PV under the Renewables Obligation for the period 2013-17: IA No: DECC0103 – 11/09/2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/6404-ia-ro-banding-consultation.pdf

Department of Energy and Climate Change [DECC] and the Department for Environment, Food and Rural Affairs [DEFRA], 2011. Anaerobic Digestion Strategy and Action Plan: A commitment to increasing energy from waste through anaerobic digestion [online] Available from http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf

Department of Enterprise Trade and Investment, 2012. Existing and confirmed ROC/MWh levels from 1 May 2013 [online] Available from http://www.detini.gov.uk/existing_and_confirmed_roc_per_mwh_levels_from_1_may_2013.pdf

Department of Trade and Industry [DTI], 2000. The Renewables Obligation: Preliminary Consultation. HMSO, London.

Department of Trade and Industry [DTI], 2006. The Energy Challenge – Energy Review – A Report – July 2006 [online] Available from http://www.decc.gov.uk/assets/decc/publications/energy_rev_06/file31890.pdf
Department of Trade and Industry [DTI], 2007. Renewable Energy: Reform of the Renewables Obligation (URN 07/636) May 2007 [online] Available from http://www.berr.gov.uk/files/file39497.pdf

Edge, G. 2006. A Harsh Environment: The Non-Fossil Fuel Obligation and the UK Renewables Industry, in K. Mallon (ed), Renewable Energy Policy and Politics: A handbook for decision-making: 163-184. Earthscan.

Electricity Networks Strategy Group [ENSG], 2009. ENSG 'Our Electricity Transmission Network: A Vision for 2020' Full Report [online] Available from http://www.ensg.gov.uk/assets/ensg_transmission_pwg_full_report_final_issue_1.pdf

Energy and Climate Change Committee [ECCC], 2011a. Solar Power Feed-in Tariffs – Volume I – 22 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1605/160502.htm

Energy and Climate Change Committee [ECCC], 2011b. Solar Power Feed-in Tariffs – Volume II – 22 December 2011 [online] Available from http://www.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/inquiries/solar-power-feed-in-tariffs/

Energy and Climate Change Committee [ECCC], 2011c. Solar Power Feed-in Tariffs: Government Response – 5 March 2012 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1858/185802.htm

Energy and Climate Change Committee [ECCC], 2012a. 11th Report – The Future of Marine Renewables in the UK – Volume I – 19 February 2012 [online] Available from http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/inquiries/the-future-of-marine-renewables-in-the-uk/

Energy and Climate Change Committee [ECCC], 2012b. 11th Report – The Future of Marine Renewables in the UK – Volume II – 19 February 2012 [online] Available from http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/inquiries/the-future-of-marine-renewables-in-the-uk/

Ernst and Young, 2007. Impact of Banding the Renewables Obligation — Costs of Electricity Production [online] Available from http://www.berr.gov.uk/files/file39038.pdf

Ernst and Young, 2009. Cost of and financial support for offshore wind – A report for the department of Energy and Climate Change: 27 April 2009: URN 09D/534 [online] Available from http://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file51142.pdf

Ernst and Young, 2011. Ernst and Young UK solar PV market outlook: The UK 50kW to 5MW solar PV market – June 2011 [online] Available from http://www.oursolarfuture.org.uk/wp-content/uploads/The-UK-50kW-to-5-MW-solar-PV-market-190611-Final.pdf

Europa, 2012. EU initiates anti-dumping investigation on solar panel imports from China: Reference: MEMO/12/647: 06/09/2012 [online] Available from http://europa.eu/rapid/press-release_MEMO-12-647_en.htm?locale=en

European Commission, 2007. Renewable Energy Road Map – Renewable energies in the 21st century: building a more sustainable future [online] Available from http://ec.europa.eu/energy/energy_policy/doc/03_renewable_energy_roadmap_en.pdf

Forum for Renewable Energy Development, 2004. Harnessing Scotland's Marine Energy Potential: Marine Energy Group (MEG) Report 2004 [online] Available from http://www.scotland.gov.uk/Resource/Doc/1086/0006191.pdf

Friends of the Earth [FOE], 2011. The Dirty half Dozen: Report – October 2011 [online] Available from http://www.foe.co.uk/resource/reports/dirty_half_dozen.pdf

Helm, 2008. Energy, the State, and the Market: British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford

Helm, D., Wadlaw, J. and Caldecott, B. 2009. Delivering a 21st Century Infrastructure for Britain – Policy Exchange [online] Available from http://www.policyexchange.org.uk/publications/category/item/delivering-a-21st-century-infrastructure-for-britain

HM Treasury, 2008. Pre-Budget Report – November 2008: Facing global challenges: Supporting people through difficult times – Cm 7484 [online] Available from http://www.hm-treasury.gov.uk/d/pbr08_completereport_1721.pdf

HM Treasury, 2009. Pre-Budget Report – December 2009: Securing the recovery: growth and opportunity – Cm 7747 [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/pbr09_completereport.pdf

HM Treasury and DECC, 2010. Energy Market Assessment – March 2010 [online] Available from http://www.decc.gov.uk/assets/decc/1_20100324143202_e_@@_budget2010energymarket.pdf

HM Treasury, 2011. Control framework for DECC levy-funded spending – March 2011 [online] Available from http://hm-treasury.gov.uk/d/control_framework_decc250311.pdf

HM Treasury, 2012. Climate Change Levy – Introduction [online] Available from http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_InfoGuides&propertyType=document&id=HMCE_CL_001174

Johnston, A., Kavali, A. and Neuhoff, K. 2007. Take-or-pay contracts for Renewables Deployment [online] Available from http://www.dspace.cam.ac.uk/bitstream/1810/194703/1/0723%26EPRG0707.pdf

Komor, P. 2004. Renewable Energy Policy. Diebold Institute for Public Policy Studies: New York.

L.E.K. Consulting and the Carbon Trust, 2006. Policy Frameworks for renewables: Analysis on policy frameworks to drive future investment in near and long-term renewable power in the UK [online] Available from http://www.carbontrust.com/media/84920/ctc610-policy-frameworks-for-renewables.pdf

Mallon, K. 2007. Renewable energy policy and politics: A handbook for decision-making. Earthscan.

Mantau, U., Saal, U., Prins, K., Lindner, M., Verkerk, H., Eggers, J., Leek, N., Oldenburger, J., Aslkalnen, A. and Antilla, P. 2010. Final Report – Real potential changes in growth and use of EU forests: EUwood: TREN/D2/491-2008: 30 June 2010 [online] Available from http://ec.europa.eu/energy/renewables/studies/doc/bioenergy/euwood_final_report.pdf

Mitchell, C., Bauknecht, D. and Connor, P. 2006. Effectiveness through risk reduction: a comparison of the renewables obligation in England and Wales and the feed-in system in Germany. *Energy Policy*: 34(3): 297-305.

Mitchell, C. and Connor, P. 2004. Renewable energy policy in the UK 1990-2003. *Energy Policy*: 32: 1935-1947

Mondaq, 2012. United Kingdom: Renewables Obligation – Is UK Solar On The ROCs? – 13 September 2012 [online] Available from http://www.mondaq.com/x/196504/Renewables/Renewables+Obligation+is+UK+Solar+on+the+ROCs

Mott MacDonald, 2011. Costs of low carbon generation technologies – May 2011: Final Report for the Committee on Climate Change [online] Available from http://hmccc.s3.amazonaws.com/Renewables%20Review/MML%20final%20report%20for%20CCC%209%20may%202011.pdf

National Audit Office [NAO], 2008. Renewable energy: options for scrutiny: A review by the National Audit Office – 1 July 2008 [online] Available from http://www.nao.org.uk/publications/0708/renewable_energy_options.aspx

National Audit Office [NAO], 2010. Government funding for developing renewable energy technologies – 10 June 2010 [online] Available from http://www.nao.org.uk/publications/1011/renewable_energy.aspx

National Archives, 1999. New and Renewable Energy: Prospects for the 21st Century – The Renewables obligation Statutory Consultation (formerly published by the Department of Trade and Industry, DTI) [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file21090.pdf

National Archives, 1989. Electricity Act 1989 [online] Available from http://www.legislation.gov.uk/ukpga/1998/46/section/44

National Archives, 2000. Utilities Act 2000 [online] Available from http://www.legislation.gov.uk/ukpga/2000/27/pdfs/ukpga_20000027_en.pdf

National Archives, 2009. The Renewables Obligation Order 2009 – Statutory Instruments – 2009 No. 785 Electricity, England and Wales [online] Available from http://www.legislation.gov.uk/uksi/2009/785/pdfs/uksi_20090785_en.pdf

National Archives, 2010a. The Renewables Obligation (Amendment) Order 2010 – Coming into force 1st April 2010 [online] Available from http://www.legislation.gov.uk/uksi/2010/1107/pdfs/uksi_20101107_en.pdf

National Archives, 2010b. The Renewables Obligation (Scotland) Amendment Order 2010 – Coming into force 1st April 2010 [online] Available from http://www.legislation.gov.uk/sdsi/2010/9780111007860/pdfs/sdsi_9780111007860_en.pdf

National Archives, 2011. Renewables Obligation (Amendment) Order 2011 – Statutory Instruments – 2011 No. 984 Electricity, England and Wales [online] Available from http://www.legislation.gov.uk/uksi/2011/984/pdfs/uksi_20110984_en.pdf

National Non-Food Crops Centre [NNFCC], 2012. Analysis: How does the renewables obligation banding review affect bioenergy – 25 July 2012 [online] Available from http://www.nnfcc.co.uk/news/how-does-the-renewables-obligation-banding-review-affect-bioenergy

Office of Gas and Electricity Markets [OFGEM], 2009. Project Discovery: Energy Market Scenarios – Consultation (Ref: 122/09) – 9th October 2009 [online] Available from http://www.ofgem.gov.uk/Markets/WhlMkts/monitoring-energy-security/Discovery/Documents1/Discovery_Scenarios_ConDoc_FINAL.pdf

Office of Gas and Electricity Markets [OFGEM], 2010. Project Discovery: Options for delivering secure and sustainable energy supplies – Consultation: Ref: 16/10: 3 February 2010 [online] Available from http://www.ebso.org.tr/b2b/ebsodergi/resimler/OFGEM_Project_Discovery_FebConDoc_FINAL.pdf

Office of Gas and Electricity Markets [OFGEM], 2011a. Renewables Obligation: What is the Renewables Obligation (RO)? [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

Office of Gas and Electricity Market Regulation [OFGEM], 2011b. The Retail market review – Findings and initial proposals: Consultation 34/11 – 21 March 2011 [online] Available from http://www.ofgem.gov.uk/Markets/RetMkts/rmr/Documents1/RMR_FINAL.pdf

Oxford Energy Research Associates (OXERA), 2007. Reform of the Renewables Obligation: What is the likely impact of the changes? [online] Available from http://www.berr.gov.uk/files/file39039.pdf

Oxford Energy Research Associates (OXERA), 2009. What is the impact of changes to the co-firing cap? Prepared for Department of Energy and Climate Change – September 2009: URN 09D/752 [online] Available from http://www.oxera.com/Oxera/media/Oxera/The-impact-of-changes-to-the-co-firing-cap.pdf?ext=.pdf

Parliamentary Office of Science and Technology [POST], 2012. Solar Photovoltaics – Number 398 January 2012 [online] Available from http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-398

Pöyry, 2011. Potential Impact Of revised Renewables Obligation Technology Bands: A report to the Department of Energy and Climate Change – December 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/4081-poyry-revised-ro-bands-review.pdf

Prest, J. 2012. The Future of Feed-in tariffs: Capacity Caps, Scheme Closures and Looming Grid Parity. Renewable Energy Law and Policy review 1(2012): 25-41.

PVTech, 2012. China dominates top ten global solar manufacturers – 27 March 2012 [online] Available from http://www.pv-tech.org/news/china_dominates_top_ten_global_solar_manufacturers

Renewable Energy Association [REA], 2012a. Publications [online] Available from http://www.ref.org.uk/publications

Renewable Energy Association [REA], 2012b. REA: Response to the Government's conclusions on RO banding levels – 25 July 2012 [online] Available from http://www.r-e-a.net/news/rea-response-to-the-governments-conclusions-on-ro-banding-levels

Renewable Energy Policy network for the 21st Century [REN21], 2012. Renewables 2012 Global Status Report – 11 June 2012 [online] Available from http://www.ren21.net/default.aspx?tabid=5434

Renewable UK, 2013. UK Wind Energy Database (UKWED) [online] Available from http://www.renewableuk.com/en/renewable-energy/wind-energy/uk-wind-energy-database/index.cfm/page/3/status/Consented/project_type/onshore

Rutledge, I. 2007. New Labour, energy policy and 'competitive markets'. Cambridge *Journal of Economics* 2007 (31): 901-925

Scottish Government, 2009a. Energy – Taking forward our National Conversation [online] Available from http://www.scotland.gov.uk/Publications/2009/11/25093815/11

Scottish Government, 2007. The Scottish Government's response to the UK Consultation on the Future of Nuclear Power – October 9 2007 [online] Available from http://www.scotland.gov.uk/Publications/2007/10/Nuclear

Scottish Government, 2008. Renewables Obligation (Scotland) Introduction of Banding: Statutory Consultation – September 2008 [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0065773.pdf

Scottish Government, 2010a. Renewable Energy – Changes to the Renewables Obligation (Scotland) Order 2010 – Statutory Consultation – August 2010 [online] Available from http://www.scotland.gov.uk/Resource/Doc/323580/0104227.pdf

Scottish Government, 2010b. Renewable Energy – Changes to the Renewables Obligation (Scotland) Order 2010 – Statutory Consultation – Government Response [online] Available from http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/17612/ROSC1210R

Scottish Government, 2011a. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011b. Renewable Energy – The Renewables Obligation (Scotland) Order 2011: Consultation on Review of ROC Bands – October 2011 [online] Available from http://www.scotland.gov.uk/Resource/Doc/361576/0122199.pdf

Scottish Government, 2012a. Renewables Obligation Banding Review 2011-12: Scottish Government Response to the Consultation – 13th September 2012 [online] Available from http://scotland.gov.uk/Resource/0040/00401801.pdf

Sinclair Knight Merz [SKM], 2012. SKM publishes report on potential for geothermal energy in Great Britain and Northern Ireland [online] Available from http://www.globalskm.com/Knowledge-and-Insights/News/2012/SKM-report-on-Geothermal-Energy-Potential-in-Great-Britain--Northern-Ireland.aspx

Toke, D. 2011. The UK offshore wind power programme: A sea-change in UK energy policy? *Energy Policy* (39): 526-534.

United Kingdom Energy research Council [UKERC], 2010. Great Expectations: The cost of offshore wind in UK waters – understanding the past and projecting the future – September 2010 [online] Available from http://www.ukerc.ac.uk/support/tiki-index.php?page=Great+Expectations%3A+The+cost+of+offshore+wind+in+UK+waters

Watson, J., Scrase, I. and Stapleton, L. 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables Target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Welsh Assembly Government, 2010. A Low Carbon Revolution – The Welsh Assembly Government Energy Policy Statement – March 2010 [online] Available from http://wales.gov.uk/about/cabinet/cabinetstatements/2010/100315energy/?lang=en

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee

Wood, G. and Dow, S. 2010. The Likely Impact of Reforming the Renewables Obligation on Renewables Targets. *International Journal of Energy Sector Management* Vol 4(2): 273-301

Wood, G. and Dow, S. 2011. What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy. *Energy Policy* 39(2011): 2228-2244

Chapter Eight

Chapter Eight

Potential constraints II: External Failures

8.1 Introduction

The previous chapter evaluated the internal failures with regard to large-scale renewable electricity deployment. This chapter is concerned with evaluating the external failures on large-scale renewable electricity technology deployment. As such, this chapter examines the external failures in four sections: planning system, public participation and engagement, electricity transmission network (grid) and policy risk. As with chapter seven, the focus of the separate sections is to determine the external failures in these areas and evaluate them with regard to deployment. The external failures are not set out in any particular order.

Section 8.2 focuses on the planning system in England and Scotland. Section 8.2.1 analyses the available planning data for the key RETs in England, Scotland and the UK overall. In contrast to chapter six which provided capacity data for operational plant only, this section analyses the amount of large-scale renewable electricity technology capacity in the planning pipeline (under construction, awaiting construction, with planning consent, awaiting planning determination and withdrawn/refused planning consent). Section 8.2.2 examines the technology-specific attributes of the various technologies with regard to planning. In particular, this section will examine the key issues facing renewable technologies within the planning system. Finally, Section 7.2.3 will examine the onshore and offshore planning systems in England and Scotland, respectively.

Section 8.3 looks at the opportunities and barriers facing public participation and engagement, with a focus on meso-scale developments and community and locally-owned projects. Section 8.3.1 examines the meaning of the term 'meso-scale' and the contribution from community renewable energy developments. Section 8.3.2 sets out the opportunities and barriers for public participation and engagement, with a focus on community scale renewable energy projects. In particular, this section will focus on onshore wind, given the high level of interest in this technology and the amount anticipated by government to be deployed in order to meet the sectoral target. Section 8.3.3 will look at the current approach to community benefits as a means of securing public consent for onshore wind developments in the UK.

Section 8.4 examines the issue of network capacity and the method of allocation and access to the electricity network with emphasis on the transmission network. Section 8.4.1 investigates the issue of upgrading the electricity transmission network with regard to connecting sufficient renewable energy generating infrastructure to meet the 2020 target. This section will look in particular at both the onshore and offshore transmission systems in the UK overall with particular emphasis on Scotland. Section 8.4.2 examines the recent or forthcoming reforms to the allocation and access to the transmission network. Both sections will focus specifically on onshore and offshore wind. As the bulk of RET infrastructure will likely connect to the transmission network, the focus of this section will be the UK electricity transmission section.

Section 8.5 focuses on policy risk from a broader perspective with a particular emphasis on the various large-scale renewable electricity subsidy mechanisms (the RO and the proposed Contracts for Difference Feed-in Tariff in so far as it affects deployment under the RO mechanism).[204] Section 8.5.1 examines policy reviews, reforms and policy risk facing large-scale renewable electricity technology deployment. In addition, chapter seven and chapter eight (sections 8.2 and 8.3) have previously evaluated policy risk with specific regard to the current subsidy mechanism, planning, public participation and engagement and electricity transmission networks, respectively.

[204] It is important to keep in mind that renewable energy policy and the various technologies do not exist in a vacuum. For example, the energy sector includes fossil fuel technologies (coal, gas and oil), low carbon technologies (nuclear, carbon capture and storage) in addition to the diverse group of technologies that comprise the renewable energy category. Alongside the supply-side technologies there is the demand-side (storage, interconnectors, smart-grids, off-grid and embedded generation and demand management) and energy efficiency and conservation (including behavioural change). In addition, there are a multitude of other factors that influence renewable electricity policy and indeed any policy approach. Although these issues are discussed where relevant to the premise of this thesis, see chapters four and five (Part II) in particular.

8.2 The planning system

The planning system is a critical enabling factor with regard to renewable energy and climate change targets. In 2011 the UK generated around 10 per cent of total electricity from renewable energy sources: by 2020, around 30-35 per cent is required to meet the sectoral target. Virtually all developments are required to obtain *a priori* planning consent. However, efforts to achieve these targets will invariably impact on the appearance and character of the physical landscape, particularly at the local level where people live (Nadaï and van der Horst, 2010). In addition, individual renewable energy technologies exhibit different attributes dependent not only on technology type but on the scale of development/deployment. These attributes include the generation output, level of geographical dispersal, plant size (in terms of acreage required for the power station) and resource availability and distribution.[205] As such, this will have a number of implications for the planning process.

The 2007 '*Planning for a Sustainable Future White Paper – May 2007*' succinctly highlights both the importance of planning and the tension that exists between social, economic and environmental objectives:

> "*Planning is of fundamental importance to the quality of people's lives. When… done well it enables thriving, healthy, sustainable communities… It supports the economic development which is vital to create jobs and ensure our continuing prosperity as a nation. It helps us to protect our natural and historic environment and ensure everyone has access to green space and unspoilt countryside. It enables the delivery of essential infrastructure which allows us to travel and enjoy access to clean, affordable energy, water and waste facilities. Planning does all this by helping us to ensure development meets economic, social and environmental objectives in an integrated and sustainable way… But people have different views of, and different interests in, the way land is used. Planning is the forum for resolving those differences…* [Also] *Planning departments and committees are one of the parts of local government that people most frequently engage with because they take a strong interest in the future development of their neighbourhood and community.*" (HM Government, 2007: 5).

[205] These attributes are discussed in Table 4.2 and in text (see chapter four).

However, the planning system has continuously been viewed as a barrier to renewable deployment for over two decades under the Non-Fossil Fuel Obligation (NFFO), the Renewables Obligation (RO) and the reformed Renewables Obligation (rRO) (AEA, 2010; ARUP, 2011; CCC, 2011; Department of Trade and Industry [DTI], 2007; Edge, 2006; European Wind Energy Association [EWEA], 2009; Loring, 2007; Mitchell, 1995; Mitchell and Connor, 2004; Toke, 2005; Toke *et al*., 2008; Watson *et al*., 2010; Wood, 2010; Wood and Dow, 2011; Woodman and Mitchell, 2011). But why is the planning system viewed as a barrier to renewable deployment. In other words, what are the major issues of the planning system with particular regard to renewable electricity technologies? Concerns exist that the planning system is too slow in granting consent, administratively burdensome in terms of complexity and cost, leads to uncertain results and fails to take into account national (and international) priorities set by legally-binding renewable and climate change targets, particularly at the local level. In addition, the planning system has often been perceived as frustrating local and central government's key political objectives (British Wind Energy Association [BWEA; now Renewables UK], 2009; Innovation, Universities, Science and Skills Committee, 2008a, b; Jones and Eiser, 2010; National Audit Office [NAO], 2008; 2010; Scottish Government, 2005; Scottish Renewables, 2010a; 2012a, b). This highlights the fundamental tensions inherent within planning: speed versus quality; democracy versus efficiency; centralisation of priority or local priority; national priorities and local interests; certainty or flexibility and consensus or conflict (Ellis, 2008). How does acquiring the correct balance of these issues affect the acceptance of RET deployment? Critically, the interrelated question is '*what kind of landscape do we want?*' (Nadaï and van der Horst, 2010).

Over recent years a number of surveys have shown that there are high levels of support for renewable energy in the UK. DECC's (2012a) annual '*Public Attitudes Tracker*' survey found that 77 per cent of people supported renewables for providing UK energy. The 2011 YouGov survey also found comparable levels of support for RET deployment. There is, however, an apparent discrepancy between general public support for renewable energy and support within the planning process with emphasis on onshore wind:

> "*Local opposition to onshore wind development seems to be on the increase… The cause of the opposition notwithstanding, the problems for developers and the government alike is that opposition groups have been shown to inhibit the chances and speed with which planning permission is obtained.*" (Jones and Eiser, 2010: 3107).

Opposition is not just confined to onshore wind power, although this is perhaps the most obvious focus of conflict: biomass and offshore wind are two further notable examples of such growing dispute (see section 8.2.2). This also highlights the importance of public participation and engagement as a critical factor (see section 8.3, page 335). In large part, local opposition in conjunction with both the concerns set out above and the view that the planning system is a barrier to development and economic growth *per se*, has provided the impetus behind the radical and rapid reform of the planning system across the UK in recent years (Department for Communities and Local Government [DCLG], 2011; Wood and Dow, 2011). The intention is to speed up and streamline the planning and decision making process and increase the deployment of RETs. This leads to a number of important questions that will be evaluated in this section: What are the implications of the recent reforms of the planning system for renewable technology deployment? Importantly, are the issues of local opposition and facilitating public participation and engagement being addressed?

As stated previously, the UK planning system is not monolithic. Since the process of devolution started in 1997 there has been continuous divergence in the planning systems of the various national administrations. Importantly, planning is largely a devolved issue to various degrees and the Devolved Administrations set policy in their respective nations. The implications of devolution and planning divergence will be examined in more detail in section 8.2.3. Although this thesis examines the barriers to renewable electricity technology deployment in the UK overall, this chapter focuses primarily on the planning systems in England and Scotland. Accounting for almost 90 per cent of total current (2011) deployment, both nations are anticipated to similarly provide the bulk of deployment required to 2020 and beyond (DECC, 2012b).[206] In

[206] The RES-E sectoral target has not been broken down into sub-national targets as the overall renewable energy target (including the heat, transport and electricity sectors) is set at the UK level. However, the various national administrations (with the exception of Wales and England) have set their own non-

addition, despite its size, Scotland has the best onshore and offshore wind resources in Europe, with almost a quarter of the total resource and has one of the most ambitious RES-E targets in the world (Troen and Peterson, 1989; Scottish Government, 2011a). Analysis has also shown that the UK requires a disproportionate contribution in terms of population size from Scotland in order to achieve the 2020 sectoral target: between 6 and 11 GW of installed renewable capacity from Scotland (Electricity Networks Strategy Group [ENSG], 2009).

Different policies and legislation exist for different scales (or capacity thresholds) of renewable developments with regard to both the onshore and offshore planning systems. These capacity thresholds, also termed '*local*' and '*national*', differ between Scotland and England, as do the linkages and overall cohesion between the local and national planning regimes that deal respectively with local and national energy infrastructure developments. Importantly, it is the legislation which is the basis of decision-making. This set out what both developers and decision-makers have to do with regard to planning applications. On the other hand, planning policy is a material consideration. As such, it is up to the decision-maker to decide the weight of such policy.

Table 8.1 (page 266) shows the main legislative and policy basis for planning in England and Scotland based on the capacity thresholds for both onshore and offshore developments. In England there are three key legislation processes: section 15 of the Planning Act 2008 for developments with an installed capacity of 50MW and above for onshore developments and 100MW and above for offshore developments. These are called Nationally Significant Infrastructure Projects (NSIP); and section 12 of the Marine and Coastal Access Act 2009 for below 100MW offshore developments and the Town and

---

legally binding targets. The Northern Ireland Executive has set a target of 40% RES-E by 2020. Scotland has introduced a target to deliver 100% electricity demand (consumption) equivalent from RES-E by 2020. The sub-national contributions towards renewable deployment in terms of installed capacity and generation output in 2011 are: England (48% and 51%, respectively), Scotland (41% and 40%, respectively), Wales (8% and 6%, respectively) and Northern Ireland (3% and 3%, respectively) (DECC, 2012b).

Table 8.1 Legislative and policy basis for onshore and offshore planning in England and Scotland

A Onshore

Development	Country	Consenting Regime	Decision Authority	Key Policy Documents
<50MW	England	Town and Country Planning Act 1990	Local Authority	National Planning Policy Framework (NPPF)
	Scotland	Town and Country Planning (Scotland) Act 1997	Local Authority	Scottish Planning Policy (SPP)
>50MW	England	Planning Act 2008	Major Infrastructure Planning Unit (MIPU)/Secretary of State (DECC)	National Policy Statements (NPSs)
	Scotland	Electricity Act 1989	Scottish Minister	National Planning Framework (NPF)

B Offshore

Development	Country	Consenting Regime	Decision Authority	Key Policy Documents
<100MW	England	Planning Act 2008	MIPU/Secretary of State (DEFRA)	Marine Policy Statement (MPS)
>100MW	England	Marine and Coastal Access Act 2009	Marine Management Organisation (MMO)/Secretary of State (DECC)	National Policy Statements (NPSs)
<1MW	Scotland	Marine (Scotland) Act 2010	Marine Scotland (MS)/Scottish Minister	Marine Policy Statement (MPS)
>1MW	Scotland	Marine (Scotland) Act 2010	Scottish Minister	National Planning Policy Framework (NPPF)

Country Planning Act 1990 for below 50MW onshore developments.[207] There are also currently three key policy documents: the National Policy Statements (NPSs) for 50MW and above onshore developments and 100MW and above for offshore developments; the National Planning Policy Framework (NPPF) for below 50MW onshore developments; and the Marine Policy Statement (MPS) for offshore developments (this is a UK-wide policy statement). In Scotland there are also three different key legislation processes: section 36 of the Electricity Act 1989 for 50MW and above onshore developments; the Town and Country Planning Act 1997 for below 50MW onshore developments; and the Marine (Scotland) Act 2010 for all offshore developments. The >50MW onshore and >1MW offshore developments, classified as national developments are the Scottish equivalent of the NSIP. On the policy side, there is the National Planning Framework (NPF) for 50MW and above onshore developments and 1MW and above offshore developments; the Scottish Planning Policy (SPP) for below 50MW onshore developments; and the MPS for all offshore developments.

This section will also focus on those RETs anticipated to contribute the majority of deployment to 2020 and beyond. Highlighted in the '*UK Renewable Energy Roadmap – July 2011*' and subsequent documents, these include onshore wind, offshore wind, biomass conversion and dedicated biomass (DECC, 2011a). Taking 2011 as the baseline for deployment, onshore wind would be required to increase by +8.4 GW, offshore wind by +16.2 GW and biomass electricity by 3.5 GW, the vast majority assumed to be accounted for by biomass conversion and dedicated biomass. Although a proportion of this capacity requirement already has planning consent (see Section 8.2.1), an evaluation of the planning system as an external failure with regard to these four technologies will be particularly valuable given that a high volume of projects are required to gain planning consent. Where relevant, however, other RETs such as solar PV and other biomass RETs will be examined in this section due to developments including the recent RO Banding Review and the substantial growth in solar PV during the last two years (see chapter seven).

[207] Other relevant legislation includes the Planning and Compulsory Purchase Act 2004 and the Localism Act 2011 (see Section 7.2.3, page 283).

This section will be set out as follows: Section 8.2.1 will analyse the available planning data for the key RETs in England, Scotland and the UK overall. Section 8.2.2 will examine the technology-specific attributes of the various RETs with regard to planning. In particular, this section will examine the key issues facing renewable technologies within the planning system. Finally, Section 8.2.3 will examine the onshore and offshore planning systems in England and Scotland, respectively.

8.2.1 An analysis of planning data in England, Scotland and the UK

This section will analyse the available planning statistics for onshore wind, offshore wind, dedicated biomass and biomass conversion. The Renewable Energy Planning Database (REPD) is the main UK governmental source of statistical information on renewable energy projects in the UK and the four national administrations (DECC, 2012c). The REPD is managed by AEA (an independent consultancy) on behalf of DECC. As such, this section necessarily relies on the database. The cut-off date for the data utilised here is November 2012.[208] However, additional sources of statistical information have been used where appropriate.[209]

8.2.1.1 Onshore wind

Table 8.2 (pages 269-270) shows the status of onshore wind planning data at the overall UK level and separately for England and Scotland. Looking at parts (a) to (d), at the UK level approximately 11 GW of onshore wind have received planning consent

---

[208] This was the date when the databases were initially accessed; this is the reason for the difference between the statistics in chapter five and this section.

[209] The REPD and the Renewable Energy STATisticS database (RESTATS) which contains performance statistics on all relevant renewable energy sources in the UK are the two key government sources of statistical information. Both databases are managed by AEA (DECC, 2012c, d,; AEA, 2012). In order to ensure accuracy, statistical information from REPD is cross-checked with data from the RESTATS and other sources including Scottish Renewables, Renewables UK and the Renewable Energy Foundation (DECC, 2012e; Renewable Energy Foundation [REF], 2012; Renewables UK, 2012; Scottish Renewables, 2012c). It is important to point out that there are omissions, errors and inconsistencies in data collection (methodology, date of source updating) in the REPD statistics used here although these do not affect the trends in deployment for the various RETs examined here.

Table 8.2: Status of onshore wind planning data in the UK, England and Scotland

(a)

>50 MW installed capacity

Pre-consent	UK		Scotland		England	
	MW	No. projects	MW	No. projects	MW	No. projects
Application approved	4,715	42	3,962	33	443	7
Application in process	2,571	30	1,956	22	54	1
Application refused	1,829	15	1,656	12	116	2
Application withdrawn	2,024	24	1,812	20	161	3
No application made	250	2	250	1	60	1
Connection applied for	977	9	977	9		

(b)

< 50 MW installed capacity

Pre-consent	UK		Scotland		England	
	MW	No. projects	MW	No. projects	MW	No. projects
Application approved	6,201	719	2,694	247	2,193	323
Application in process	3,570	619	1,771	213	805	120
Application refused	3,632	326	1,662	123	1,613	173
Application withdrawn	1,671	180	815	66	597	89
No application made	184	16	119	7	65	9

(c)

Post-consent	UK		Scotland		England	
	MW	No. projects	MW	No. projects	MW	No. projects
Operational	1,623	16	1,378	12	191	3
Under construction	1,206	10	1,152	9	54	1
Awaiting construction	1,886	16	1,432	12	198	3

(d)

Post-consent	UK		Scotland		England	
	MW	No. projects	MW	No. projects	MW	No. projects
Operational	2,691	314	1,343	114	772	143
Under construction	1,102	71	394	25	518	34
Awaiting construction	2,408	317	954	106	861	136
Abandoned	66	13	2.9	2	42	10

Table 8.2: Continued

(e)

Average time (months) from submission to determination in the UK

	UK		Scotland		England	
	>50MW	<50MW	>50MW	<50MW	>50MW	<50MW
2007	41.1 (3)	16.1 (97)	43.8 (2)	21.9 (26)	35.7 (1)	11.7 (54)
2008	34.6 (10)	15.2 (97)	36.1 (8)	18.8 (32)	28.5 (2)	11.1 (54)
2009	31.8 (4)	15.6 (126)	31.7 (4)	15.6 (50)	-	12.3 (61)
2010	36.7 (9)	13.8 (122)	38.6 (5)	16.7 (37)	37 (3)	8.4 (64)
2011	42 (4)	15.3 (157)	42 (4)	15.5 (62)	-	10.6 (84)
2012	30.1 (6)	11.7 (160)	30.2 (5)	10.7 (73)	31.8 (1)	11.2 (51)

Note: Tables (a) to (d) use statistical information from when records began in 1991 onwards. * Data for Wales and Northern Ireland are subsumed within the UK data.

(‘*application approved*’ since records began; this category includes those projects ‘*operational*’, ‘*under construction*’ or ‘*awaiting construction*’). In terms of scale, just over half of all consented projects fall under the local planning authority jurisdiction: 43 per cent (4,715 MW) of all projects consented are 50 MW or above and 57 per cent (6,201 MW) below the 50 MW threshold capacity. When the number of projects (or individual wind farms) is examined, 94 per cent (702 wind farms) are under 50 MW with just 6 per cent (42 wind farms) with an installed capacity of 50 MW or above.

Almost two-thirds of all consented projects are either operational (4.3 GW, or 40 per cent of total consented projects) or under construction (2.3 GW, or 21 per cent of total consented projects) and thus will be operational in the near future. Although not all of the awaiting construction capacity will become operational, there is the equivalent amount of installed capacity awaiting construction as there is currently in operation (4.3 GW, or 39 per cent of total consented projects). The proportion of developments that fall within the <50MW and >50MW division is roughly the same for operational, under construction and awaiting construction categories as that found for ‘*application approved*’.[210]

At the sub-national level, Table 8.2 (a) to (d) reveals a stark difference between Scotland and England (and Wales and Northern Ireland). Scotland dominates UK onshore wind in terms of both current capacity (2,720MW, or 63 per cent of total UK operational onshore wind capacity and over two-thirds of total UK capacity under construction) and potential capacity (2,386MW, or 56 per cent of total UK capacity awaiting construction and 3,727MW, or 61 per cent of total UK capacity in the planning process (planning application submitted but not yet determined). In contrast, England has just over a fifth of total UK operational capacity (964 MW, or 22 per cent). In addition, England accounts for only a quarter of total UK consented capacity both under construction (25 per cent,

[210] At the UK level: Operational projects (57% <50 MW (non-section 36); Under Construction (52% <50MW); Awaiting Construction (44% <50MW). This is also the same for the 6,141MW of capacity in the ‘*applications in progress*’ where planning applications have been submitted (58% <50MW).

or 572 MW) and awaiting construction (25 per cent, or 1,059 MW). In terms of the number of operational wind farms, despite accounting for significantly less installed capacity, 45 per cent (or 146 developments) are located in England in comparison to 38 per cent (or 126 developments) in Scotland. The vast majority of the onshore wind farms in England are less than 50 MW installed capacity (80 per cent contra 20 per cent for above 50 MW of capacity). In Scotland, onshore wind farms are equally distributed across the capacity threshold (<50 and >50 MW), resulting in a larger average wind farm size than in England. However, Scotland accounts for 85 per cent of total UK above 50 MW operational wind farms contra just 12 per cent in England and 50 per cent of <50 MW wind farms contra 29 per cent in England. Significantly, 83 per cent of total consented (applications approved) capacity in England is for projects that fall under local authority jurisdiction.

In terms of the number of wind farms (or number of projects) operational and under construction, Scotland and England currently account for 83 per cent of the UK total. England accounts for 44 per cent (181) of the total UK wind farms contra 39 per cent (160 projects) in Scotland. The inclusion of projects in the awaiting construction category result in an increase in the number of onshore wind farms in England: (43 per cent, or 320 projects) contra 37 per cent (or 278 projects) in Scotland. In contrast, when applications in process (submitted) are included, Scotland accounts for more projects than England: 37 per cent (513) contra 32 per cent (442), respectively. Although highly unlikely that all projects awaiting construction or are applications in process will ultimately become operational, it is interesting to note that the combined total, when these two categories are added to the operational and under construction categories, declines to around two-thirds (69 per cent). In other words, the potential contribution of Wales and Northern Ireland is anticipated to increase in the future although this would depend on a number of critical factors including approval rates.

There have been more onshore wind farms refused planning consent in terms of installed capacity and number of wind farms than there are operational sites: 5,452 MW (341 projects) contra 4,314 MW (330 projects). However, if the under construction category is added to the amount of operational wind farms, there would be more installed capacity (6,622 MW) and wind farms (411). Scotland accounted for the largest proportion of refusals, with 3,318 MW or 61 per cent of the UK total refused consent. There was no statistical distinction between >50 MW and <50 MW projects in Scotland, although Scotland accounted for 91 per cent of total >50 MW refusals in the UK. In comparison, although England accounted for only 32 per cent of the total UK refusal rate, this equated almost double the current operational rate (1, 729 MW). Of this, 93 per cent was attributed to onshore wind farms with an installed capacity of below 50 MW. The withdrawal rate is also high, with 3,695 MW (or 204 projects) withdrawn at some point prior to determination. Decisions to withdraw a project are varied and rarely publicised; however, caution is required regarding such statistics as projects can be resubmitted at a later date and the development could change in terms of installed capacity and location.

Part (e) of Table 8.2 shows the average time in months for an onshore wind project to obtain planning determination (whether consent or refusal) from submission. Importantly, this does not take into account the pre-application stage. Although front-loading was introduced to increase certainty and confidence in the planning system by resolving as many issues as possible prior to submission, there are concerns that it could increase both costs and time. This is partly due to the hands-off role of PINS in advising developers, leading to difficulties in balancing speed and caution (Offshore Wind Cost Reduction Task Force, 2012).[211] It is clear from part (e) that the overall UK average time taken to determination has declined over the period for both categories (<50MW and >50MW), with the rate of reduction roughly approximate (around a third of the time shorter between 2007 and 2012). Overall, then, part (e) shows that the length of time that developers are required to wait for a planning application decision is improving at the UK overall level, thus indicating improvement in this area. However, caution is required for two reasons: (1) the data for 2012 does not include part of November and the entire month of December for that year; and (2) for 2010 and 2011, determination times actually rose for both Scotland and England (and thus the UK overall).

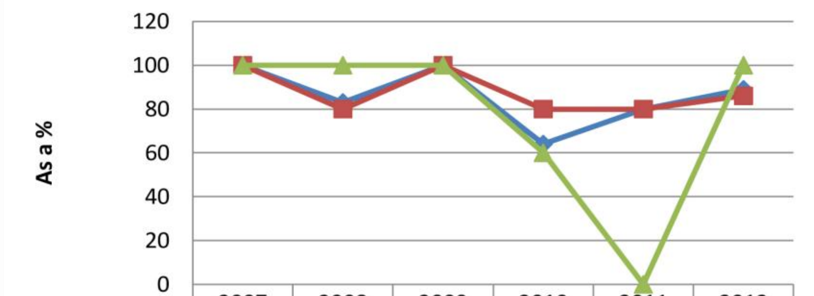
[211] This pre-application stage also applies to offshore wind (see also Section 8.3).

On average, however, it takes considerably longer to gain determination (planning decision) for onshore wind farm developments >50MW than it does for <50MW. This is to be expected: above 50MW projects are more complex (for example, in terms of landscape impact and the number of stakeholders and affected land users involved). Although the time taken from submission to determination is broadly comparable in 2012 (Scotland is slightly quicker on average), this was not always the case: Prior to 2012, project developers waited significantly longer in Scotland than they did in England for both >50MW and <50MW decisions, despite significantly less <50MW projects in the planning regime in contrast to England. In other words, Scotland has experienced a more dramatic reduction for both categories (<50MW and >50MW); indeed, the overall UK average reduction in time taken from submission to determination appears to be primarily driven by the planning experience in Scotland. In contrast, the time taken to reach determination in England has fallen insignificantly between 2007 and 2012, in particular for <50MW developments despite the vast majority of current (operational) and future (under construction and awaiting construction) deployment falling in this category.

Figure 8.1 (page 275) shows the approval rates as percentages for onshore wind farms in the UK, Scotland and England for <50MW and >50MW developments by scheme (number of wind farms) and installed capacity (in MW). When looking at approval rates for >50MW (requiring central government consent), it is important to note that there is typically high annual variation due to the limited number of such large-scale applications in the planning process. This is particularly true for England, and is reflected in part (a). However, approval rates by both scheme and installed capacity (part c) are consistently above 60 per cent (except 2011 for England where no >50MW projects were approved). Scotland shows more variation as 80 per cent of all UK >50MW projects that have been approved are located here. Approval rates for <50MW (see parts (b) and (d), in contrast, show a decreasing trend overall during the period 2007 to 2012 at the UK overall level and Scotland and England. Although Scotland shows a decline from 74 per cent in 2007 to 52 per cent in 2012, approval rates in England exhibit a more substantial decline from 72 per cent to 29 per cent over the same time period.

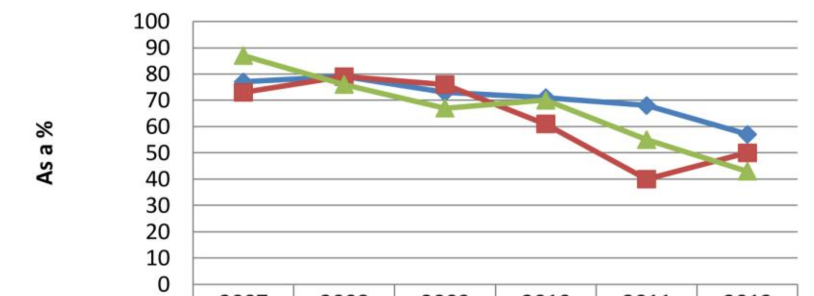
Figure 8.1: Approval rates of >50 MW and<50 MW for onshore wind in the UK, England and Scotland - 2007 to 2012

(a) Approval rates as a percentage by scheme (>50 MW)



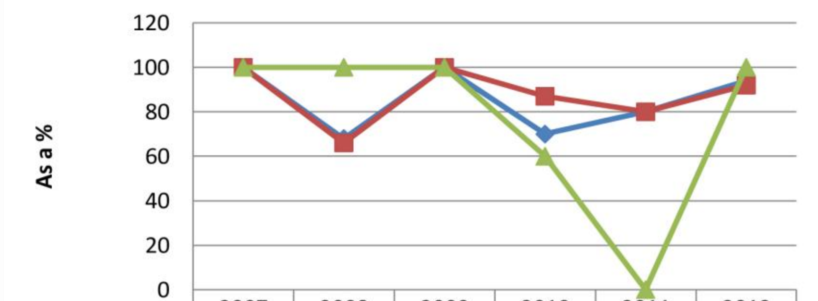
	2007	2008	2009	2010	2011	2012
UK	100	83	100	64	80	89
Scotland	100	80	100	80	80	86
England	100	100	100	60	0	100

(b) Approval rates as a percentage by scheme (<50 MW)



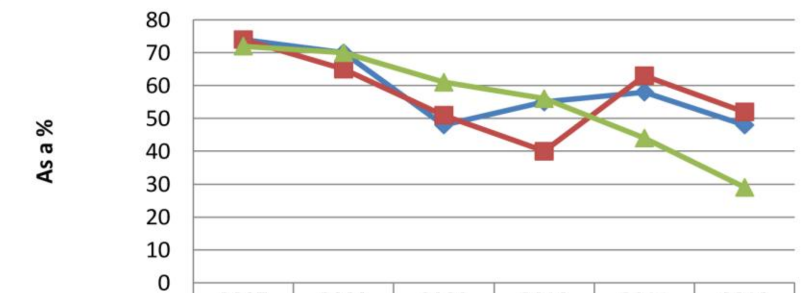
	2007	2008	2009	2010	2011	2012
UK	77	79	73	71	68	57
Scotland	73	79	76	61	40	50
England	87	76	67	70	55	43

(c) Approval rates as a percentage by MW (>50 MW)



	2007	2008	2009	2010	2011	2012
UK	100	68	100	70	80	94
Scotland	100	66	100	87	80	92
England	100	100	100	60	0	100

(d) Approval rates as a percentage by MW (<50 MW)



	2007	2008	2009	2010	2011	2012
UK	74	70	48	55	58	48
Scotland	74	65	51	40	63	52
England	72	70	61	56	44	29

Note : Wales and Northern Ireland data subsumed within the UK overall data.

Figure 8.2 (page 277) shows the average size of onshore wind farms in terms of installed capacity for >50MW and <50MW categories over the same time period. Although it is difficult to determine trends in the data set due to the relatively few number of >50MW developments, a number of relevant points can be made. Looking at >50MW developments, part (a) shows that although there is significantly more annual variation in size (a reflection of the higher number of >50 MW developments located in Scotland), the average size of onshore wind farms is considerably larger than in England. In contrast, the analysis for England shows a relatively stable average size between 2007 and 2012. An examination of the average size of <50MW developments, however, reveals a different trend shared by both countries: the average size has dropped by around 50 per cent over the last six years. This can be particularly seen in Scotland, particularly due to the significantly larger average <50MW development size in 2007. Overall, however, <50MW onshore wind farms remain larger in Scotland in comparison to England.

8.2.1.2 Offshore wind

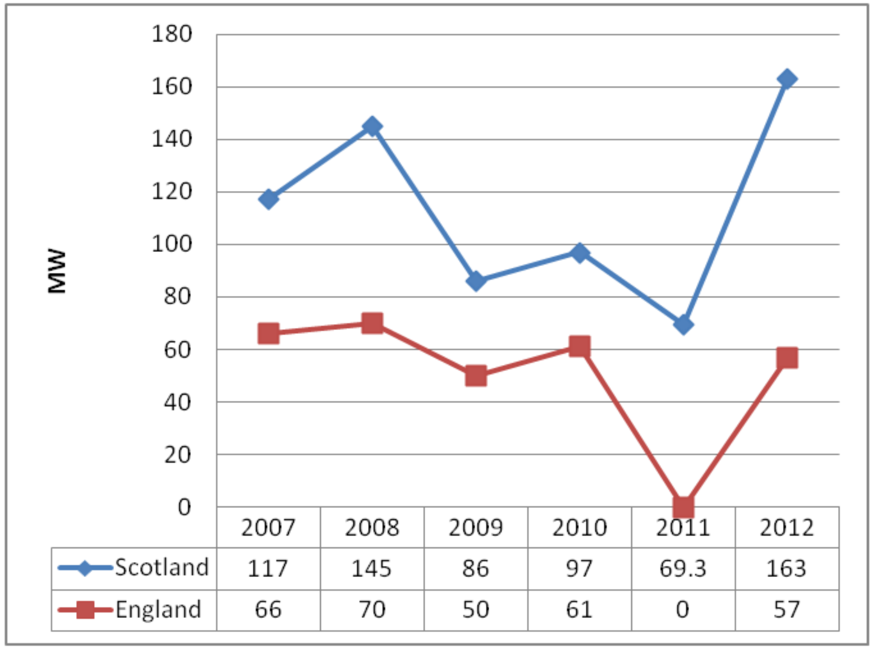
Table 8.3 (page 278) shows the status of offshore wind planning data at the UK overall level and separately for England and Scotland.[212] As of November 2012, at the UK level, there are 20 projects operational (2,679MW, although this figure from REPD does not reflect that fact that not all turbines within offshore wind farms have been fully commissioned).[213] In addition, there is a further 1,538MW (4 projects) and +2,017MW (7 projects) either under construction or awaiting construction, respectively. In total, there are 32 projects (6,342MW) with planning consent and a further 12 projects (6,092MW) in the process of obtaining planning consent. This shows that although

[212] Wales is the only other country that has deployed and/or currently has offshore wind developments in the planning pipeline: 726MW (3 projects) with planning consent ('application approved'). Of this, 130MW (2 projects) are operational with a further 576MW (1 project) under construction. There is also a further 108MW (1 project) withdrawn.

[213] Typically offshore wind farm developments are carried out in phases, with a certain proportion of turbines connected to the grid and operational at different stages in the development of the entire farm. This is the reason why statistics released from DECC covering the period to December 31st 2012 show that there were only 2,530MW of offshore wind capacity installed in the UK.

Figure 8.2: Average size of >50 MW and <50 MW onshore wind in the UK, England and Scotland - 2007 to 2012

(a) Average size of onshore wind farm (>50 MW)



(b) Average size of onshore wind farm (<50 MW)

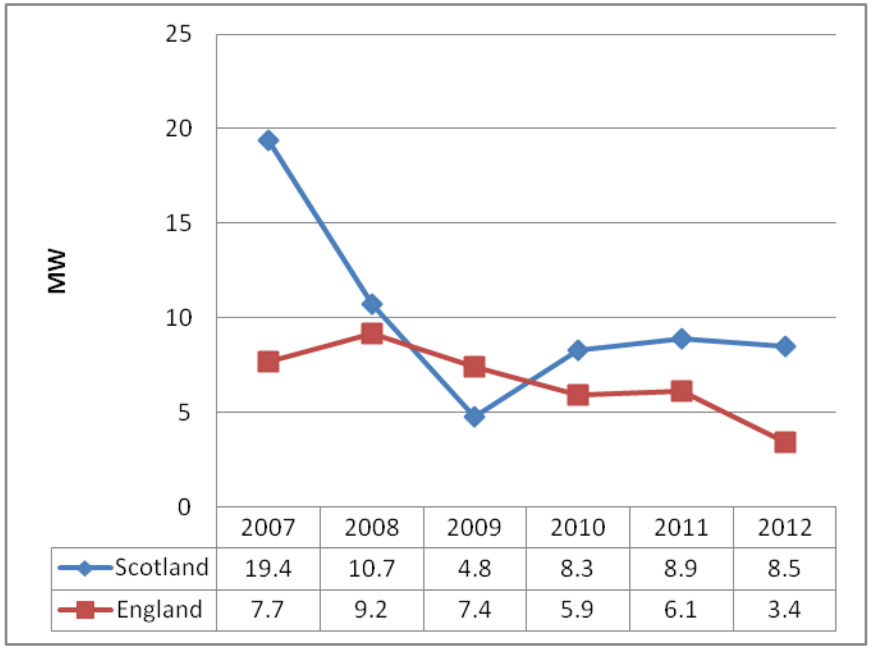


Table 8.3: Status of offshore wind planning data in the UK and Scotland - 2000 to 2012

Pre-consent	UK		England		Scotland	
	MW	No. projects	MW	No. projects	MW	No. projects
Application approved	6,342	32	5,421	25	196	3
Application submitted	6,092	12	2,095	5	3,997	7
Application refused	540	1	540	1	-	-
Application withdrawn	392	2	284	1	-	-
No application made	1,233	6	155	1	1,078	4

Post-consent	UK		England		Scotland	
	MW	No. projects	MW	No. projects	MW	No. projects
Operational	2,679	20	2,394	15	190	2
Under construction	1,538	4	962	3	-	-
Awaiting construction	2,017	7	2,011	6	6	1
Abandoned	108	1	108	1	-	-

Average time (months) from submission to determination

	UK	Scotland
2002	20 (2)	-
2003	11 (6)	13 (2)
2004	24 (2)	-
2005	24 (4)	-
2006	23 (4)	5 (1)
2007	26 (1)	-
2008	26 (5)	-
2009	29 (1)	-
2010	-	-
2011	30 (3)	26 (1)
2012	44 (3)	-

Average time (months) from determination to commissioning

	UK	Scotland
2000	29 (1)	-
2003	17 (1)	-
2004	17 (1)	-
2005	33 (1)	-
2006	40 (1)	-
2007	15 (1)	14 (1)
2008	53 (2)	-
2009	65 (4)	79 (1)
2010	62 (3)	90 (1)
2011	47 (1)	-
2012	58 (4)	-

UK offshore wind approval rates as a percentage and (in MW)

Year of approval	1998	2002	2003	2004	2005	2006	2007	2008	2010	2010	2011	2012
MW	108	60	634	194	-	1,030	754	1,191	-	-	476	1,260
%	100%	100%	100%	100%	-	100%	100%	100%	-	-	100%	43%

Cumulative offshore wind deployment in the United Kingdom (in MW)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
MW	4	4	63	123	213	303	393	586	941	1,341	1,838	2,530

offshore wind is a relatively recent newcomer to the UK renewable electricity technology deployment landscape, operational capacity is already approximately 60 per cent of total UK onshore wind capacity. Further, although not all capacity will become operational (see below regarding refusal, withdrawn and approval rates), there is around 12.4GW either with planning consent or currently under consideration ('*applications approved*' and '*application submitted*', respectively).

In contrast to onshore wind, England accounts for the overwhelming majority of offshore wind development in the post-consent planning regime: 90 per cent of operational capacity (2,394MW), 100 per cent of capacity under construction (962MW) and over 99 per cent of capacity awaiting construction (2,011MW). According to the REPD database, Scotland accounts for 190MW of offshore capacity (with just 6 MW awaiting construction): however, 180MW is actually designated to England due to the transmission cable connecting to the grid in England. When the '*application submitted*' category is examined, however, Scotland accounts for a greater proportion of potential capacity coming through the planning pipeline: 66 per cent (3,997MW) in comparison to 34 per cent (2,095 MW) in England. However, as the large-scale Crown Estate Round 3 projects progress, this is likely to change. Of relevance, there is also a further 35GW of offshore wind potential capacity coming through the various Crown Estate offshore wind leasing programmes (in the development pipeline).[214] As with onshore wind, in particular >50 MW developments, caution regarding the interpretation of the offshore wind data set is required due to the small number of projects and the significantly large size (capacity) of the individual developments (see also below regarding the average time required for receiving planning determination and from determination to commissioning).

According to the REPD database, only one project (540 MW, Docking Shoal) has so far been refused planning consent. The significance of this is that approval rates have been 100 per cent with the exception of 2012 where it dropped to 43 per cent due to Docking

[214] Round 3 (31,015MW), Scottish Territorial Waters or STW (3,385MW) and the Northern Ireland Offshore Renewable Energy Programme (600MW) (Wood and Taylor, 2012).

Shoal being refused planning consent. With a trend towards increasingly large developments with overall few actual projects, approval rates could fluctuate quite significantly on an annual basis even though capacity could increase substantially. Therefore, it is currently difficult to ascertain what the planning approval rates will be for offshore wind due to limited experience. However, the REPD refusal rate is also misleading: Scarweather Sands (108 MW, Crown Estates Round 1 leasing programme) was withdrawn from the planning process as it would have failed to gain planning consent if submitted (Wood and Taylor, 2012). Again, according to the REPD 392 MW of projects have been withdrawn: however, a more detailed analysis shows that almost 3 GW have actually been withdrawn.[215] Undoubtedly, a number of these projects would have been withdrawn for non-planning reasons (for example, financial and pre-planning issues arising during the Crown Estates offshore wind leasing programme) but it is likely that planning issues would have affected at least some of the 3 GW in question.[216] There is also the issue of downsizing. As issues arise as the development goes through the planning regime, it is fairly typical for the number of turbines (and thus overall capacity) to be reduced in order to address or counter problems including environmental, public opposition and landscape issues. So far, around 300 MW of capacity has been lost to downsizing; however, the Atlantic Array offshore wind farm project has recently had capacity cut by 20 per cent (from 1.5 to 1.2 GW) due to planning (environmental) concerns (Business Green, 2012a, b).

In contrast to onshore wind, the average time taken from submitting an offshore wind planning application to receiving a decision (in months) has increased between 2002 and 2012 (see Table 8.2). The time taken to obtain consent for round 2 projects is significantly longer than that experienced for Round 1 projects: all but one round 1

---

[215] Withdrawn rates from the five Crown Estates offshore wind leasing programmes: Round 1 (498MW), Round 2.5 (147MW) and Round 4 (Scottish Territorial Waters or STW) (2,198MW) (Wood and Taylor, 2012).

[216] Companies do not typically publish the reasons for why particular projects are withdrawn. Therefore, the amount actually withdrawn due to planning issues is virtually impossible to determine. Further, as projects progressed through the Crown Estates offshore wind leasing programme, it is to be expected that a proportion would be 'withdrawn' as problems arose prior to reaching a licensing agreement which in itself is not a guarantee of planning permission (Wood and Taylor, 2012).

project was determined within 15 months in contrast to only 2 out of 10 round 2 projects as of the end of 2011. Indeed, round 2 projects are driving the increase in time overall. Although this should be expected due to the increasingly large projects coming into development, the overall complexity of an offshore wind farm application and the relatively limited experience in processing this type of planning application, one of the major reasons behind both reforming the Renewables Obligation and the planning regime was to side-step deployment constraints including planning that were increasingly being viewed as a significant factor in limiting onshore wind deployment in the UK (Wood and Dow, 2011).[217]

8.2.1.3 Biomass conversion and dedicated biomass

Table 8.4 (page 282-283) shows the status of two key biomass electricity technologies, dedicated biomass and biomass conversion. Co-firing is also included in the analysis here. As part (a) and (b) show, at the UK level there is 4,917MW (240 projects) in the '*application approved*' category at both the <50 and >50MW deployment scale. In terms of installed capacity, the majority of applications fall under <50 MW: 61 per cent (2,986MW >50MW, or 15 projects) whilst the majority of projects fall within the <50MW category (39 per cent, 1,931MW, or 225 projects). In relative terms, there is significantly less capacity under construction (204MW) in comparison to capacity awaiting construction (3,171MW, of which 78 per cent falls in the >50MW category). Indeed, there is over twice the capacity awaiting construction as there is currently operational (1,121MW).

England has historically and continues to dominate dedicated biomass and biomass conversion deployment[218] (and for other biomass RETs, including sewage gas and landfill gas) at both the >50 and <50 MW scale: 2,871 MW (or 96 per cent of total UK applications approved at >50 MW) and 953MW (or 50 per cent at <50 MW). Within the application approved category, England accounts for 88 per cent of total UK operational dedicated biomass and biomass conversion (94 per cent and 73 per cent at the >50 and

[217] Table 7.5 also shows that the average time taken from receiving planning consent to commissioning the offshore wind farm is increasing between 2000 and 2012.

[218] This is also the case for other biomass electricity RETs including sewage gas and landfill gas (see Chapter Six, page 192).

Table 8.4 Status of dedicated biomass, biomass conversion and co-firing biomass planning data in the UK

(a)

Section 36 (>50 MW installed capacity)

Pre-consent	UK		England		Scotland		Post-consent	UK		England		Scotland	
	MW	No. projects	MW	No. projects	MW	No. projects		MW	No. projects	MW	No. projects	MW	No. projects
Application approved	2,986	15	2,871	13	115	2	Operational	800	2	750	1	50	1
Application submitted	360	3			360	3	Under construction	65	1			65	1
Application refused							Awaiting construction	2,480	13	1,831	11		
Application withdrawn	265	3	145	2	120	1	Abandoned	290	1	290	1		

(b)

Non-section 36 (< 50 MW installed capacity)

Pre-consent	UK		England		Scotland		Post-consent	UK		England		Scotland	
	MW	No. projects	MW	No. projects	MW	No. projects		MW	No. projects	MW	No. projects	MW	No. projects
Application approved	1,931	225	953	177	172	30	Operational	321	69	235	55	69	13
Application submitted	343	46	248	32	43	8	Under construction	139	26	92	20	47	5
Application refused	226	15	171	13	5	1	Awaiting construction	691	112	509	89	52	12
Application withdrawn	150	12	132	9	3	2	Abandoned	148	18	132	15	5.5	2

Table 8.4 Continued

(c) Average time (months) from submission to determination in the UK

	s36	non-s36
2002		3
2003		4
2004		8
2005	23	3
2006		8
2007	14	4
2008	17	7
2009	19	6
2010	16	7
2011	18	7
2012	18	6

(d) Average time (months) from determination to commissioning in the UK

	s36	non-s36
2002		39
2003		
2004		
2005		11
2006		19
2007	33	21
2008		14
2009		31
2010		24
2011		24
2012	10	21

(e) UK biomass approval rates as a percentage and in MW

	Year	2006	2007	2008	2009	2010	2011	2012
s36	MW		350		60	395	2050	615
	%		100		100	100	100	100
non-s36	MW	52	24	98	134	251	106	150
	%	100	71	100	71	96	79	97

<50 MW levels, respectively). The other category of interest here is awaiting construction. England again dominates projects with planning consent: 74 per cent of >50 and <50 MW capacity (1,831 MW and 509 MW, respectively). When the '*applications submitted*' category is examined, however, Scotland dominates the >50 MW category with 100 per cent of applications although England accounts for 73 per cent of capacity <50 MW. At the UK overall level, there is only 703 MW awaiting planning determination.

In particular, biomass conversion (whether partial or full conversion of existing coal or oil power station units to biomass) is a new development which most research has not anticipated until recently. As of 2013, planning permission has been granted for five coal-fired power stations to convert, either partially or fully to biomass: including Tilbury power station which commenced operation at the beginning of 2012, these stations has the combined capacity of 6 GW.[219]

Part c of Table 8.4 shows the average time taken from submission of the planning application to determination in months for >50 MW and <50 MW developments. As with >50 MW onshore and offshore wind projects, >50 MW dedicated biomass and biomass conversion RETs take longer to reach a planning decision than <50 MW projects. Although the time required has fallen for the >50 MW category, it has approximately doubled for <50 MW projects although this is still a third of the time taken for >50 MW in 2012. Of interest, although there is limited data (particularly for >50 MW), the average time from determination to the biomass plant becoming operational appears to decline between 2002 and 2012 (see Table 8.4, part d). When the approval rates for both capacity categories is examined (part e), it is clear that the large-scale projects have consistently experienced 100 per cent approval rates in

---

[219] The five stations are: Tilbury (750MW, already operational as of early 2012); the other four are in the process of conversion (Ironbridge (1,000MW, full conversion in progress), Drax (3,960MW, partial conversion of 1,980MW in progress), Eggborough (2,000MW, full conversion not yet commenced) and Alcan Lynemouth (420MW, full conversion, decision to progress imminent) (Biofuelwatch, 2013; Drax Group Plc, 2012; Eggborough Power, 2013; E.ON, 2013). With the exception of Tilbury, these power stations are not included in the REPD database. When existing and potential future capacity from other biomass electricity RETs is combined, this could arguably be called a '*dash for biomass*'.

obtaining planning consent. In contrast, approval rates for <50 MW developments have been more varied annually although approval rates have consistently remained in excess of 70 per cent.

8.2.2 The planning system and renewable electricity technology deployment

There are a number of key issues facing renewable electricity technologies within the planning process. These issues centre on the '*landscape*':

> "*Whilst large sections of the population in developed countries are indeed in principle in favour of renewables, in practice proposed facilities have often given rise to considerable public concerns. Members of the public raise a multitude of issues, but the one concern that is raised time and time again across different renewable energy technologies, local or national contexts, is that of the impacts on 'the landscape'.*" (Nadaï and van der Horst, 2010: 1).

But what does '*landscape impact*' mean in this context? A broad term that is often insufficiently unpacked, it includes visual impact, aesthetic, social, historical, political and emotional value of a particular landscape (or place attachment), issues of biodiversity and ecological loss and the industrialisation of previously non-industrialised land (Ellis, 2008; Haggett, 2008, 2011; Wolsink, 2007). In a sense, these are generic in scope, with regard to not just renewable technologies but all developments to varying extent. However, there are certain attributes for particular RETs, primarily onshore wind power and biomass that aggravate these issues (see below). Specific issues for RETs include noise and radar/aviation disturbance (wind) and greenhouse gas and particulate/non-GHG pollution emissions for certain biomass and waste RETs. Critically, there are also the cumulative impacts of development across the landscape (Royal Society of Birds [RSPB], 2009). These are the key issues that play a role in the acceptance of such technologies in particular from a public acceptance/planning perspective.

It is important to keep in mind that the key issues examined here are complex and often inter-linked:

> "... [T]*here are (at least) two sides in every case of dispute or conflict, and multiple actors are involved in every project development. Public responses are not developed in a vacuum or in the abstract, but rather in interaction with others who have an interest in a development – particularly those who are advocating and promoting it. Thus, rather than seeing people as predisposed to oppose or support particular developments, we might view local responses as 'emergent, negotiated and shifting' in relationship to a variety of contextual factors.*" (Walker *et al*., 2011: 4).

It also becomes apparent that a number of the key issues are invariably subjective. With regard to RETs, there will be some people who like the actual technology or structure from an aesthetic point of view, or accept or believe the necessity for the technology over other considerations (for example, the global good versus local good or the need to transition from an unsustainable to sustainable energy source). Likewise, others will dislike the development for often contrasting reasons. The appropriate siting of RETs is of particular significance with respect to the above: the inappropriate siting of RET deployment in the landscape can mobilise hostility and opposition, can damage fragile wildlife and habitats through habitat loss, degradation, mortality and a range of different disturbance effects. This can particularly affect breeding populations of long-lived bird and animal species, migratory species and environmentally important habitats such as feeding and over-wintering grounds, upland and blanket bog areas and peatland which is a significant source of stored carbon dioxide in the UK in general and Scotland in particular (RSPB, 2009).

The heterogeneity of renewable electricity technologies and the scale of the proposed development is also an important consideration here. A number of RETs can be deployed at a range of scales, from pico or micro, to the small, meso and large-scale (Walker and Cass, 2011). As such, they can be scaled-up (large-scale) or scaled-down (meso-scale or smaller), and this has important implications for RES-E deployment for a number of internal (see Chapter Six) and external failures, including planning, grid and public participation and engagement. Regarding planning, meso-scale deployment has been argued to be more acceptable to the public in terms of acceptance than large-scale developments. The participation and engagement of various communities, co-operatives and smaller firms and organisations (including local authorities, farmers and small and independent energy companies as opposed to multinationals and former utilities) has also been argued to facilitate the obtaining of planning consent (Toke and van der Horst, 2010; Warren and McFadyen 2008; Watson *et al*., 2010).[220]

Table 8.5 (page 288) shows the key planning issues and the relative impacts of a number of renewable electricity technologies with regard to their particular 'set' of attributes (see below). The assumption used in analysing the data here is that this is an evaluation of the overall impact of particular RETs with regard to planning, rather than examining the impact at the local (or individual project) scale. This is in keeping with the systemic approach adopted throughout the thesis (see Chapter One). Woodman (2008: 57) makes the important point that renewable energy is not special in the context of the planning system:

> "*Of course, the planning process raises hurdles for all technology options, including delays in obtaining consent, the costs of participating in inquiry processes, and high degrees of uncertainty for developers and local communities about the prospects of any particular project proceeding.*"

There are a number of attributes more-or-less specific to renewable electricity technologies, however, that arguably make RETs unique with regard to the issue of planning. In contrast to fossil fuel and low carbon generating plant, RETs are generally small-scale in terms of generating output but exhibit significantly higher levels of geographic dispersal and individual plant size (acreage under or in development). This results in the need for a large number of geographically dispersed individual renewable generating stations not only required to 'match' conventional or low carbon output but also due to the significant deployment of RETs required to meet both renewable and climate change targets. Efforts to achieve the national and international targets will invariably impact on the appearance of the landscape. Accommodating the additional capacity required to meet the targets within a strict timetable will invariably increase the level of impact. Typically the siting of a renewable electricity generation station is determined by the quality of resource availability or access to the resource in the case of

---

[220] Although there are a number of important caveats here, including the level and type of ownership. This will be looked at in more detail in Section 7.3 on public participation and engagement.

Table 8.5 Key issues for renewable electricity technologies and the planning system in the United Kingdom

	Wind power		Marine						
Key issues	Onshore	Offshore	Wave	Tidal stream	Solar PV	Hydro	Biomass	Waste	Geothermal
Landscape (visual) impact	**	**	?	?	*	* – ** [2]	*	*	*
Noise	**	* [1]	?	?	*	* [1]	*	*	*
Biodiversity	**	**	?	?	*	* – ** [2]	* – ** [3]	*	*
Radar disturbance	**	**	*	*	*	*	*	*	*
Cumulative impact	**	?	?	?	*	*	*	*	*
Contested space	**	**	**	**	*	*	*	* – ** [4]	*
Greenhouse gas emissions	*	*	*	*	*	*	* – ** [5]	*	*
Particulate/pollution emissions	*	*	*	*	*	*	* – ** [5]	* – ** [5]	*

Note: *equates to low or no impact. ** equates to high impact. ? - currently not enough data/research on marine RETs. [1] Noise primarily due to construction and future decommissioning stages. [2] High impact is attributed here to large-scale hydro power installations that require significant structures and reservoirs. [3] High impact here is attributed to potential biodiversity issues regarding the growing of biomass feedstock (such as land use change, clearance, use of biocides/pesticides) required for the plant rather than the generation plant per se. [4] Electricity generated from waste facilities can be either located away from where people live (e.g. landfill gas) or close/within towns and cities (e.g. incineration, etc). [5] The range for biomass and waste depends on the type of RET and fuel required. Some biomass RETs have negligible GHG emissions but others have substantial GHG emission profiles (see Chapter Three, Table 3.1 and text, page 98). There is also the issue of particulate and non-GHG pollution emissions including dioxins, furans and other toxins that have significant health risks (Friends of the Earth [FOE], 2011a).

biomass and waste technologies. Not all RETs show the same attributes, however, due to the varied range of renewable electricity technologies.

It is clear from Table 8.5 that both onshore and offshore wind has the highest impact on the key issues examined here. As mentioned previously, there is little real-time deployment experience for marine technologies in the UK and abroad. (ECCC, 2012). These technologies do, however, exhibit the same general attributes as wind power with regard to small generation output, large plant size and geographic dispersion rates.[221] As deployment increases and the size of the developments increases, particularly post-2020, wave and tidal stream are likely to show at least comparable levels of impact on the key issues examined in Table 8.5. In contrast to wind power, all other RETs show a relatively reduced impact. Solar PV, geothermal and hydro exhibit relatively low geographical dispersal (as the resource distribution and/or quality is constrained compared to the UK's wind resource base) and small plant size.[222] However, solar PV can be scaled up in terms of plant size. The concentration of the resource in the southern part of the UK in general and the southwest in particular and if solar PV deployment above the domestic/building scale increases, this is likely to lead to a higher impact on a number of the key issues although the technology is less visible and intrusive than wind power.

Biomass has similar attributes to the previous three technologies; however there are a number of important differences. The difference is that biomass plants (and large-scale hydro) can exhibit generation output on a scale similar to conventional electricity

[221] By design, however, the majority of wave and tidal stream devices will not be as prominent as either onshore or offshore wind turbines. Tidal stream will present different issues from wave power due to the particular resource-geography characteristics as there is limited high-resource sites located around the UK shores. As with offshore wind, both technologies will still require existing or new/reinforced onshore infrastructure (Engineering the Future Alliance, 2011)

[222] This is not to detract from arguments regarding the local impact of these generating stations. In particular, biomass and waste plants are often situated close to where people live. This can be especially the case for waste and biomass and concern additional critical issues including greenhouse gas emissions and particulate/pollution emissions (see below).

generation plant resulting in the requirement of fewer individual stations.[223] This is particularly the case for biomass conversion and dedicated biomass (and also co-firing). It is the need for access to the resource, such as major transport infrastructure including road and port facilities that play an important role in determining the location of such plant and this can put them into conflict with other users.[224] There is also the issue of GHG emissions and particulate/pollution emissions: although it depends on the type of feedstock and biomass technology, in general biomass is unique among RETs in that it exhibits a high impact on these particular sustainability concerns. These concerns also include the source and sustainability of biomass fuels (land use change, production, use of pesticides/fertilisers, harvesting, transporting, drying, processing and conversion) (RSPB, 2012a).

This serves to highlight the point that the planning system cannot be viewed as a barrier to the deployment of renewable electricity technologies *per se*; RETs have quite varying attributes, technical specifications and design requirements that are more or less contentious with regard to obtaining planning consent. The majority of the issues highlighted in Table 8.5 are particularly acute for onshore wind. This technology has a very high level of geographic dispersal and large plant size. On the one hand, onshore wind sites are often located in remote, peripheral and undeveloped areas (in particular, rural, wild and island areas). These sites are quite often the same locations that people value due to the lack of development. On the other hand, onshore wind farms can also be located in close proximity to urban areas due in part to the ability to connect to the distribution grid (RSPB, 2009; Woodman, 2008). Due to project economics, in part strongly driven by the RO mechanism, onshore wind farms need to be located in the areas of highest resource quality. This is primarily due to the subsidy level being offered

[223] Although there are large-scale hydro plants alongside towns (e.g. Pitlochry, Scotland) there is limited opportunity in terms of resource availability and acceptability for further large-scale plant to be deployed in the UK, particularly due to environmental and social issues. In contrast, there is apparently significant scope for small-scale hydro deployment, the majority in Scotland (DECC and Welsh Assembly Government, 2010; Palmer, 2005; Scottish Government, 2008).

[224] For example, Forth Energy (a joint venture between Forth Ports, the owner and operator of 7 commercial ports and manager of 289 miles^2 of navigational waters in the UK and Scottish and Southern Energy) has plans to develop three wood fuel biomass electricity generation plants in Scotland with a combined installed capacity of 360 MW (Forth Energy, 2012).

on an output basis irrespective of the deployment location or the size of the development (see also chapter seven). The best wind resource availability areas are typically in elevated and flat coastal areas, resulting in the turbines being visible from a long distance. With around 326 operational wind farms (or approximately 3,162 turbines) and a further 81 wind farms under construction, not to mention those awaiting construction (343 farms) and in the development pipeline (649 farms), the scale of onshore wind development is becoming increasingly important and this raises a number of key challenges: the easier large sites (those with few objections, low wildlife interest and good grid connections) have been developed (RSPB, 2011a). With increasing numbers of sub-50MW onshore wind farms under construction, awaiting construction or where planning applications have been submitted (1,007 contra 314 currently operational), it is important to note that

> "*These can still have the potential to result in significant harm to wildlife if poorly sited or designed and assessment is still time consuming. Overall, this could lead to an increase in processing time per MW installed. As more onshore wind* [both >50 MW and <50 MW] *in particular is deployed, cumulative impacts on wildlife and landscape are becoming an increasing concern.*" (RSPB, 2011b: 5).

In addition, as onshore wind energy generation capacity is expected to continue to grow, "Planning authorities are more frequently having to consider turbines within lower-lying more populated areas." (Scottish Government, 2012a: 1). In other words, onshore wind farms are increasingly likely to be located in areas with increased conflict over landscape and visual impact and thus land use. Unlike a number of other RETs including solar PV and hydro (at the small-scale), onshore wind turbines cannot be screened from view as wind flows to the plant cannot be 'blocked'. In other words, wind turbines produce the most blatant landscape changes of any renewable energy technology (Pasqualetti, 2011).

The attributes of onshore wind, then, account for the high level of impact on the key issues examined in table 8.5, in particular for the issues of landscape and visual impact. This also has increased relevance for other key issues such as radar/aviation disturbance, biodiversity and noise. There are 5 GW of onshore wind and 7 GW of offshore wind projects in scoping, planning and awaiting construction that are impacted by radar: almost 2 GW of onshore wind awaiting construction are being held up by the need for developers to meet planning conditions related to radar despite being consented over 2 years ago (DECC, 2011a). Given the importance of Scotland in meeting the UK overall sectoral target, radar/aviation concerns are especially sensitive due to the close proximity of three major airports (Glasgow International, Edinburgh and Glasgow Prestwick) (DECC, 2011a). The particular attributes of onshore wind in conjunction with the anticipated growth in deployment of the technology lead to conflicts over the siting of onshore wind farms in the UK. The UK terrestrial landmass is a highly contested landscape (see above). It also has one of the highest population densities in the world (260 people per km^2), although this is heavily dependent by nation and specific area: England (383), Scotland (65), Wales (142) and Northern Ireland (125) (Barrow, 2012).

Importantly, the marine environment is not as uncontested as has been previously perceived, particularly in comparison with the terrestrial environment and onshore wind (Wood and Taylor, 2012). This is despite the policy aim to shift renewable deployment to the marine environment specifically to avoid constraints including planning and public opposition (Wood and Dow, 2011). Offshore wind, wave and tidal stream technologies represent a relatively new and potentially significant spatial conflict in the use of the UK's offshore region at a time when human activity in this area is increasing in type and intensity and larger portions of the seas are portioned off, dedicated for specific, often exclusive uses. These conflicts include fishing, tourism and recreational purposes, open sea/ocean aquaculture, dredging, shipping lanes, gas/oil industry, defence and aviation and environmental/landscape/birds and wildlife/conservation concerns.

Offshore renewables also do not mean they will always have little or no impact onshore and the UK coastline is heavily inhabited and/or heavily contested. Currently, the majority of operational offshore wind farms are sited close to shore in shallow waters to facilitate learning through deployment experience and to keep costs down (European Wind Energy Association [EWEA], 2012; UK Energy Research Centre [UKERC], 2010). In addition, a significant number of projects already under construction or consented will not be any further from the coast (4Coffshore, 2012a; Toke, 2011). Offshore wind farms are increasingly being built further from the coast in deeper waters via the Crown Estates Offshore Wind Leasing Programme (in particular Round 3, see below). In conjunction with the trend through time for substantially larger plant size on a scale significantly larger than for onshore wind with increased geographical dispersal, this will increase the impact of offshore wind on the marine and terrestrial environment with resultant implications for planning. There is also the issue of connecting offshore renewable assets to the electricity network, which will require both an offshore and onshore component. Additionally, constructing offshore (and later, wave) technologies further from shore in an attempt to mitigate planning concerns carries with it the danger of a trade-off in reducing the costs of such technology deployment at least in the short and possible medium-term.

Critically, those technologies with the attributes most likely to aggravate the major planning issues for RETs are also the same technologies likely to be deployed the most to meet the targets. If deployment continues on the trends necessary for attaining the 2020 sectoral target, and the deployment focus remains primarily on onshore and offshore wind, the issue of cumulative impact, which has particular implications for onshore wind, will only increase.

8.2.3 The planning system in England and Scotland

The planning system is undergoing the most radical and rapid change since the 1940s across the UK (Moore and Purdue, 2012). A devolved issue, there has also been a divergence in the both the terrestrial (onshore) and marine (offshore) planning systems in operation within the various national administrations. Although energy policy is overall a reserved matter for Westminster, in reality it sits on the dividing line between devolved and reserved powers for Scottish Ministers and UK Ministers, respectively. As seen in Chapter Six, Scotland has a degree of operational control over the Renewables Obligation Scotland (ROS), but only in so far as determining the subsidy level for various

RETs or 'eligibility rules' through the banding mechanism.[225] Indeed, the area where Scottish Ministers can exert major influence over energy policy lies in the Scottish Government's control over major energy generation and electricity transmission planning consents through the devolution process. Despite these divergences, the planning systems are based on the same original principles and a number of notable similarities exist between the two systems.

8.2.3.1 The onshore planning system in England and Scotland

Table 8.6 (see pages 295-297) shows the key onshore planning legislation and policy documents for England and Scotland. The Planning Act 2008 in England and the Planning Etc. (Scotland) Act 2006 created a new development consent regime for Nationally Significant Infrastructure Projects (NSIP) (called national developments in Scotland) with regard to energy. The aim of both Acts is to speed up and streamline the process for this scale of development. Section 15 of the Planning Act 2008 sets out the capacity threshold by which certain types of development are considered as NSIP: for renewable and all energy installations, this is more than 50 MW and 100 MW for onshore and offshore generating stations in England and Wales, respectively; section 16 of the Act sets out the capacity threshold for above ground electric lines of 132 kilovolts (kV) or more in England and Wales (UK Government, 2009). In contrast to England, Scotland retained the power under the Electricity Act 1989: under section 36 of the Electricity Act applications for power stations are considered by Scottish Ministers where they are in excess of 50 MW for all onshore renewable energy developments (UK Government, 1989).[226] There is also a transmission network voltage threshold

[225] In contrast, market arrangements, the electricity network and broad policy approach operate at the UK overall level. Scotland also has some control over discretionary economic development spending and indeed has invested heavily in the funding of research and demonstration facilities for offshore wind and marine RETs.

[226] Prior to 2011 hydro power was the sole exception. Under the Electricity Act 1989 (Requirement of Consent for Hydro-electric Generating Stations (Scotland) Order 1990, the capacity threshold was set at 1 MW. Hydro stations <1 MW were considered by the relevant local authority whilst stations above this limit were considered by Scottish Ministers (UK Government, 1990b). This was revoked in 2011 by The Electricity Act 1989 (Requirement of Consent for Hydro-electric Generating Stations (Scotland) Revocation Order 2011 (Scottish Government, 2011b). This brought hydro power and Scotland into line with the situation in England and Wales (Scottish Government, 2011c).

Table 8.6 Key planning legislation and policy documents for onshore renewable energy installations and associated infrastructure in England and Scotland

Key legislation/policy	Information
(a) England	
Town and Country Planning Act 1990	Applications for renewable energy installations of 50 MW and below for onshore renewables are dealt with at local authority level
Planning and Compulsory Purchase Act 2004	To abolish all structure plans, local plans, and unitary development plans and replace with a new single level of plan called the Local Development Plan Framework (or 'local development plans').
Planning Act 2008	To speed up and ensure a more efficient process for translating national policy objectives into decisions on Nationally Significant Infrastructure Set out the threshold for renewable energy deployments over 50 MW onshore and 100 MW offshore and electricity lines at or above 132kV To establish National Policy Statements (NPS) to provide the basis for planning decisions on Nationally Significant Infrastructure To establish the Independent Planning Commission (IPC) to take over responsibility for making decisions on Nationally Significant Infrastructure (now abolished, see below) A single consent regime - developers will generally only need to submit one application instead of the numerous applications which often had to be made under the previous regime A new duty - and greater onus - on promoters to ensure that proposals are properly prepared and consulted on before they submit an application for development consent Aim for decisions on projects to be typically made in under a year from the application date
Localism Act 2011	Abolishes the Regional Strategies Imposes a new 'Duty to Cooperate' on local authorities and other public bodies to work together on planning issues Abolish the IPC - the functions of examining applications taken on by a new Major Infrastructure Planning Unit (MIPU) within the Planning Inspectorate (PINS) and the function of determining applications on major energy infrastructure projects by the Secretary of State for Energy and Climate Change (who would receive a report and recommendation on each such application from MIPU) Introduces Neighbourhood Development Plans which have to take into account national policy and the local plan

Table 8.6 Continued

National Policy Statements (NPS) (designated July 2011)	To provide the basis for rapid, predictable, coherent and accountable planning decisions on Nationally Significant Energy Infrastructure - 6 NPS (an overarching Energy NPS and one each for renewables, nuclear, fossil fuels, transmission networks and oil and gas pipelines) and integrate environmental, social and economic objectives and provide clarity on the need for infrastructure Sets out national policy for relevant energy infrastructure - the overarching energy NPS (EN-1) in combination with the relevant technology specific NPS (EN-2 to EN-6) provides the primary basis for decisions by the MIPU. The NPS is also likely to be a material consideration in decision making under the Town and Country Planning Act 1990 (as amended) and may be a relevant consideration under the Marine and Coastal Access Act 2009 (the NPS prevails for purposes of MIPU decision making in the event of any conflict with the Marine Planning documents (including Marine Policy Statements (MPS) and Marine Plans (MP) As energy policy is generally a matter reserved to UK Ministers, the energy NPS may therefore be a relevant consideration in planning decisions in Scotland
National Planning Policy Framework (NPPF) (March 2012)	To replace the majority of the Planning Policy Statements (PPS), Planning Policy Guidance Notes, Minerals Policy Statements, Minerals Planning Guidance Notes into a single concise document covering all major forms of development proposals handled by local authorities. The NPPF must be taken into account in the preparation of local and neighbourhood plans, and is a material consideration in planning decisions
(b) Scotland	
Town and Country Planning Act (Scotland) 1997	Applications for renewable energy installations of 50 MW and below for onshore renewables are dealt with at local authority level
The Planning Etc. (Scotland) Act 2006	Introduction of a 'hierarchy of planning' (development management) based strongly on the use of development plans to permit the planning system to be able to respond to different types of planning proposals. Four levels of development: national, major, local and minor To abolish the system of structure and local plans and replace with Local Development Plans (LDP) prepared by local authorities and Strategic Development Plans (SDP) in the city regions in addition to the relevant LDPs Establish a National Planning Framework (NPF) - a statutory based strategy for Scotland's long term spatial development and a statement of what Scottish ministers consider to be priorities for development. The NPF designates specified developments as national developments, thereby establishing the need for the development. Although not a development plan, LDPs and SDPs must take into account the NPF (the NPF is a material consideration). The Scottish Executive decides after consultation on which national developments should be included in the NPF Note: Scottish Ministers consider applications for renewable energy installations exceeding 50 MW, offshore renewables as well as overhead power lines

Table 8.6 Continued

	Note: Scottish Ministers consider applications for renewable energy installations exceeding 50 MW, offshore renewables as well as overhead power lines
Scottish Planning Policy (SPP) (February 2010)	The Scottish Planning Policy (SPP) is a statement of Scottish Government policy on nationally important land use matters. SPP updates and consolidates previous Scottish planning policy documents into a single statement of the Scottish Government's strategy for Scotland's long term spatial development. SPP covers the purpose and operation of the planning system, provides statutory guidance on sustainable development and planning and gives subject-specific advice (for example, on renewable energy). The policies expressed in SPP should inform the content of development plans (LDPs and SDPs) - it is a material consideration in the determination of planning applications

SOURCES: (a) Department for Communities and Local Government [DCLG], 2012; DECC (2011b, c); FOE (2010, 2011b, 2012); Moore and Purdue (2012); Sheate *et al*., 2011; UK Government (1990a, 2004, 2008, 2011). **(b)** Collar (2010); Scottish Government (2006, 2009a, 2010a); Slater (2010); Wood (2010).

difference between Scotland and England. Under section 37 of the Electricity Act 1989, an electric line in Scotland which has a nominal voltage exceeding 20 kV requires consent from Scottish Ministers and below this under the control of the local planning authority (National grid, 2011; UK Government, 1989).[227] Developments below the threshold capacity set by the Planning Act 2008 and the Electricity Act 1989 are under the jurisdiction of the relevant local authority (UK Government, 1990a).[228]

The abolishment of the Infrastructure Planning Commission (IPC) has brought arrangements in line with that found in Scotland where Scottish Ministers retain jurisdiction over national developments. Instead of NSIP being decided by an independent commission separated from the direct control of the relevant Secretary of State, the Localism Act 2011 introduced the Major Infrastructure Planning Unit (MIPU), an agency within the Planning Inspectorate (IP) on 6 April 2012 (UK Government, 2011).[229] This is the main significance of the replacement of the IPC for NSIP designated energy developments. Although the Secretary of State is legally responsible for accepting and examining applications, the UK Government has delegated this responsibility to the MIPU. The final decision on major infrastructure applications, however, reverts to the Secretary of State.[230] Otherwise, the Localism Act retained most of the previous procedures for how the decisions will be consulted on and made despite

---

[227] However, it is unlikely that this is a significant difference from England given that the majority of new onshore transmission infrastructure will be lower than the 128 kV threshold set under the Planning Act 2008 (ENSG, 2009).

[228] However, there are a number of proposed changes at the local planning authority level (for sub-50 MW renewable developments) (see below).

[229] Section 128 of the Localism Act 2011 sets out the transition from the IPC to the MIPU, an existing agency of the Department of Communities and Local Government (House of Commons Library, 2012). The IPS was a body independent from Government with the power to give a unified consent order (to give planning decisions, compulsory purchase) and thus charged with making the final decisions about major or NSIP Projects. Significant opposition to the IPC focused around the following issues: the IPC was a non-democratically elected commission that was not directly accountable to Parliament (an annual report was to be submitted to Parliament to account for money spent but not for the decisions made); and it had virtually complete discretion about whether and how the public could be heard within the planning process (removed public inquiries where the public could cross examine and produce witnesses) (FOE, 2010a).

[230] Prior to the Planning Act 2008 decisions would have been taken by the Secretary of State following a public inquiry (House of Commons Library, 2012).

this being an area of contention under the IPC (DECC, 2011d). This includes an emphasis on the use of written representations and the aim to minimise the need for issues to be examined through cross-examination at public inquiries. A public inquiry can be held if there is an issue of local impact but the MIPU controls the examination of each application, including deciding the principal issues to be examined and has discretion to decide whether cross-examination of evidence will take place at hearings (Planning Help, 2012). The MIPU must have regard to any local impact report submitted by a relevant local authority, any relevant matters prescribed in regulations, the Marine Policy Statement (MPS) and any applicable Marine Plan (MP) (see below on marine planning) (DECC, 2011d).

The Planning Act 2008 also introduced a new system of issuing planning consent for NSIP to be administered by the MIPU. The National Policy Statements (NPS) provide the basis for planning decisions on NSIP by setting out national policy in relation to one or more specified descriptions of development.[231] The importance and opportunity of the NPS is succinctly pointed out in a report by the Energy and Climate Change Committee [ECCC] (2011: 3):

> "*The National Policy Statements will influence the development of a green economy in Britain and could accelerate progress towards greater energy security. Bottlenecks in the planning process have been extremely costly and prolonged in the past, as it has been necessary to debate national policy before large infrastructure projects could be consented. The NPSs offer an opportunity to state that policy clearly. If introduced correctly, the NPSs will help to make Britain an attractive place to invest in clean low carbon energy.*"

The reasoning behind the NPS are as follows: to speed up NSIP development by providing rapid, predictable, coherent and accountable planning decisions; to integrate environmental, economic and social objectives; and by providing justification for the need for energy infrastructure the NPS (DECC, 2011d). The six energy NPS covering all energy infrastructure including generating, gas and oil pipelines and the electricity network were designated by the Secretary of State with responsibility for the relevant

---

[231] Part 2(5) provides the legal basis of the various NPS (UK Government, 2008).

policy (in this case DECC) on the 19 July 2011 (DECC, 2011c).[232] In addition to the overarching energy NPS (EN-1), there are two specific NPS of relevance to renewable energy: EN-2 (renewable energy infrastructure) and EN-5 (electricity network infrastructure). For energy NSIP, EN-1, when combined with the relevant technology-specific energy NPS, is a material consideration for decisions by the MIPU. However, as such they can be ignored as it is not binding.

The suite of energy NPS form a new tier in the set of planning documents with the purpose to define government policy in order to make timely and necessary decisions on applications for planning consent for NSIP. In particular,

> "*The NPSs are intended to help deliver that investment by streamlining the planning process for major infrastructure projects and providing certainty for investors.*" (ECCC, 2011: 31).[233]

However, the role of the NPS is not just with regard to major infrastructure developments but also sits within the wider planning system, at most scales and for both terrestrial and marine planning. The linkage of the NPS to the wider planning system is problematic and the terminology regarding the role of the energy NPS, however, is at times vague: EN-1 '*may be helpful*' to local planning authorities preparing their local impact reports; EN-1 '*is likely to be*' a material consideration in decision making that fall under the Town and Country planning Act 1990 in England and Wales; EN-1, in combination with the technology-specific NPS (EN-2 to 6), '*may be*' a relevant consideration for the Marine Management Organisation (MMO) when it is determining

---

[232] There are 12 designated or proposed NPS setting out Government policy on different types of national infrastructure developments covering Energy, Transport (ports, transport networks (including rail and roads) and aviation) and Water, Waste Water and Waste NPS (water supply, hazardous waste and waste water treatment). The Energy NPS include: an overarching Energy NPS (EN-1) that sets out generic considerations for all energy infrastructure and five technology specific ones for fossil fuel electricity generating infrastructure NPS (EN-2), renewable energy infrastructure NPS (EN-3), gas supply infrastructure and gas and oil pipelines NPS (EN-4), electricity networks infrastructure NPS (EN-5) and nuclear power generation NPS (EN-6) (DECC, 2011c; The Planning Inspectorate, 2012).

[233] Section 19(2) of the Planning and Compulsory Purchase Act 2004 places a duty for local planning authorities to have regard to national policies when preparing development plans (UK Government, 2004). This includes the NPS. However, "*... the degree to which Government policy is relevant to any particular planning application and the weight to be attached to it is a matter for the decision maker according to the circumstances of the particular case.*" (DECC, 2011f: 31).

applications in accordance with the MPS and MP (and the preparation of the marine plans) (DECC, 2011d). This has the potential to lead to disruption, uncertainty and conflict in the planning system rather than provide the certainty required to make the necessary investment in meeting the RES-E sectoral target and other objectives (see below).

There is also the issue of the need for new energy NSIP. Modelling in the DECC publication '*Updated Energy and Emissions Projections (UEP)*' (DECC, 2011e) indicates that up to 59 GW of new electricity generating capacity is urgently '*needed*' by 2025: of this total, 18 GW is required from RES-E sources and 18 GW from non-renewable capacity.[234] A number of reasons are put forward to justify this need: the closure of around 25 per cent of UK electricity generating plant by the same time period due to the closure (already and in the near future) of existing generating plant due to environmental and/or age constraints and the requirement of Government to meet its energy security, decarbonisation and climate change objectives. However, there are a number of significant concerns regarding the need case. Although section 5(5)(a) of the Planning Act 2008 states that the NPS may

> "*... set out, in relation to a specified description of development, the amount, type or size of development of that description which is appropriate nationally or for a specified area.*" (UK Government, 2008: 3)

In actual fact the energy NPS

> "*... almost entirely duck this question. The conclusion is simply that we are likely to need a lot more of everything, and indeed that we should plan for significantly in excess of what we actually need because not all of it may come forward for development, or because there is a need for spare capacity. The* [MIPU/Secretary of State] *is therefore not allowed to question this assumption or need, or that there may be more acceptable alternatives to any given proposal... this means that the*

[234] Currently there is a total of 85 GW of electricity generating capacity in the UK. UEP modelling indicates that around 113 GW will be required by 2025, of which 59 GW of new capacity is needed. This is the high estimate of the modelling. This is split into 33 GW of renewable capacity (or 18 GW once operational (13 GW) and already under construction (2 GW) is taken into account) and 26 GW of non-renewable capacity (or 18 GW once the 8 GW already under construction is taken into account) (DECC, 2011e).

> *NPSs are a developers' charter. They are also a blunt tool, establishing an overwhelming need for new infrastructure.*" (Scrase, 2011: 11-12).

It can be argued that the case for unlimited, '*one-dimensional*' need for all forms of energy infrastructure has not been made (Campaign to protect Rural England [CPRE], 2011).[235] In addition, the UEP modelling does not take into account the number of projects already with planning consent that have not yet started construction (around 10 GW in 2010) and the figure of 59 GW is the upper estimate derived from the UEP modelling (DECC, 2011e). In particular, EN-1 states that "*It is for industry to propose new energy infrastructure projects.*" (DECC, 2011f: 16). Critically, a failure to specify the amount, type or size of development could result in the inability of the MIPU to prevent the over-consenting of gas-fired capacity. This could result in a second 'dash-for-gas' scenario.[236] There is also the issue of greenhouse gas (GHG) emissions in addition to non-GHG/particulate emissions from fossil fuel plant and certain biomass RETs (see Section 7.2.2, page 274). Indeed EN-1 states that:

> "*The role of the planning system is to provide a framework which permits the construction of whatever Government – and players in the market – have identified as the types of infrastructure we need in the places where it is acceptable in planning terms.*" (DECC, 2011f: 9).

[235] The NPS, for example, do not fully take into account existing plant that will either apply for life extensions or undergo conversion: EDF, the owner of around 9 GW of UK nuclear generating plant recently confirmed that it would extend the lifespan of all the advanced gas cooled reactors (7.5 GW, excluding Sizewell B which is a Pressurised Water Reactor) by an average of seven years (Business Green, 2012c). There are also coal-fired power stations that are either closing and converting to gas (Cockenzie, 1 GW CCGT conversion) or converting to biomass (Tilbury, 850 MW; DRAX, 1,980 MW, proposed) (DRAX, 2012; RWE npower, 2012; Scottish Power, 2013). The implications are that the UK will require less new plant, or rather that there is a reduced urgency for new generating plant at least in the short and medium term.

[236] Bloomberg New Energy Finance (2012:6) already reports that "*… the UK is in the midst of its second dash for gas having already built 4.5GW of CCGTs since 2010 with a further two large projects (RWE's 2GW Pembroke [already online] and EDF's 1.3GW West Burton [already partial commissioning, total plant online 2013] due online in 2012.*" In the most recent 'Seven year Statement' National Grid (2011) expect around 12GW to come online by 2016, including 6.8GW already with planning permission with 1.5GW of plant delayed until 2016. The UK Gas Strategy (DECC, 2012f) anticipates between 26-37GW of new CCGT plant online by 2030.

This is a fundamental shift in the role of the planning system established in '*Planning Policy Statement 1 – Delivering Sustainable Development*' (PPS 1) that the planning system operates

> "*… in the public interest to ensure the development and use of land results in better places to live, the delivery of development where communities need it, as well as protection and enhancement of the natural and historic environment and the countryside. The outcomes from planning affect everyone, and everyone must therefore have the opportunity to play a role in delivering effective and inclusive planning. Community involvement is vitally important to planning and the achievement of sustainable development.*" (Office of the Deputy Prime Minister, 2005: 15, paragraph 40).

The primary implication of EN-1 is that it imposes the NSIP on local areas and local communities and favours development and developers. This could result in communities becoming disenfranchised and placed at the mercy of more powerful developers and landowners (National planning Forum, 2009). By limiting public engagement and participation the new system runs the significant risk of unjustifiably alienating support in those very projects that Government deems there is a critical need for. In combination with leaving technology choice and siting partly to industry (and a current Government strongly predisposed towards gas, see above), albeit within the planning system framework, this could result in unnecessary conflict and delays. This can only end in concomitant impacts on renewable and low carbon investment being challenged and even constrained with repercussions for statutory renewable and climate change commitments.

This also leads directly to the issue that the energy NPS do not provide any direction on decarbonisation of the electricity sector. In particular, the MIPU does not have to take into account the greenhouse gas emissions of generating plant in general or the sustainability of biomass fuel sources in particular. Yet these are two key issues for biomass and waste technology developments with regard to planning, particularly due to concerns over the lifecycle GHG emissions of certain RETs and the environmental and social impact of unsustainably sourced (or transported) feedstock from abroad.[237] Instead this is left to the Renewables Obligation, a financial subsidy mechanism designed to provide financial support to developers/investors (see chapter seven).

Section (1)(5)(b) of the Planning Act 2008 also sets out the power for energy NSP to include criteria relating to specific locations. However, with the exception of EN-6 (nuclear power generation) none of the other NPS take into account site-specific or '*strategic spatial planning*' (ECCC, 2011). This is partly due to the NPS leaving decisions (on amount, type, size and location) of NSIP to industry, but also due to the priority of the NPS over local plans. Such a market-led approach to major infrastructure development results in the NPS undermining a plan-led approach to energy development and the fact that there is little evidence of spatial planning in England in comparison to the devolved administrations. This is significant given that the NPS could have permitted the consideration of environmental considerations up front in the development of future infrastructure so that siting issues can be avoided or minimised (Scrase, 2011).

Another issue of particular contention is the point that the planning system (in England and Scotland) does not establish any '*no-go*' areas for developers to put forward planning applications. From a natural environment perspective, although there are a number of designated areas protected by law from the national and international level down to regional and local level,[238] including ancient woodland and veteran trees in addition to the protection of species and habitats that receive statutory protection under a range of legislative provisions,[239] there are a number of caveats that need to be taken into account. EN-1 (DECC, 2011d: 44) states that

[237] Other key issues include the transportation of the feedstock to the plant and other non-GHG particulate pollution emissions.

[238] Such designations include National Parks, The Broads, Areas of Outstanding Natural Beauty (AONB), Green Belt, Natura 2000 sites (including Special Protected Areas (SPAs), Special Areas of Conservation (SACs) and potential Special Protection Areas (pSPAs), Ramsar sites, Sites of Special Scientific Interest (SSSIs), Regionally Important Geological Sites, Local Nature Reserves and Local Sites (DECC, 2011d).

[239] Examples of such protected species include Badgers, Bats, Seals, Whales and other Cetaceans (Reid, 2009).

> "*Given the level and urgency of need for infrastructure of the types covered by the energy NPSs… the IPC* [MIPU] *should start with a presumption in favour of granting consent to applications for energy NSIPs. That presumption applies unless any more specific and relevant policies set out in the relevant NPSs clearly indicate that consent should be refused.*"

For example, although the National Parks, The Broads and Areas of Outstanding Natural Beauty (AONB) are afforded the highest level of protection in relation to landscape and scenic beauty[240], development consent can be granted '*in exceptional circumstances*': such circumstances include the need for the (energy infrastructure) development as set out in the NPS; the impact of consenting or not consenting it upon the local economy and the capacity to moderate any detrimental effect on the environment and landscape. An examination of the other designated areas also has exceptions where development can go ahead for various reasons: although proposed projects outside National Parks will be visible from within the designated area and thus may have an impact within them "*… should not in itself be a reason for refusing consent.*" (DECC, 2011d: 97).

In other words, energy infrastructure deployment is examined in the planning system on a 'criteria' basis rather than a 'no-go' or exclusion basis through the designation of planning zones for energy infrastructure and zones free from such development. In essence, a criteria-based approach

> "*… involves study of whether the windfarm meets various standards, mainly environmental and safety criteria, rather than whether the proposed site is on the right or wrong side of what may be an arbitrarily drawn line on a map.*" Toke (2010: 532).

A criteria-based approach obviously has merits, being pragmatic and based as it should be on the particular case-by-case considerations of the proposed development from an evidence-based perspective. However, this approach has the potential to aggravate public fears of development being able to occur anywhere. This is particularly the case for onshore wind developments, given the attributes of this RET and the current and

---

240 EN-1 (DECC, 2011d: 96) states that: "*The conservation of the natural beauty of the landscape and countryside* [of these designated areas] *should be given substantial weight by the IPC in deciding on applications for development consent in these areas.*"

projected levels of deployment, and could lead to increased public hostility as deployment increases.

A major change to planning in Scotland is the introduction of a '*hierarchy of planning*' based strongly on the use of development plans. The aim of this is to permit the planning system to be able to respond to different types of development proposals in an appropriate way to their scale and complexity. There are four levels to the hierarchy: national developments, major developments, local developments and minor developments. Section 3A(4)(b) of the 2006 Act provides that the National Planning Framework (NPF) may describe a development and designate it, or a class of development and designate each development within that class as a national development (Scottish Government, 2009b). Scottish Ministers are responsible for the NPF. National developments are those projects considered of long-term national strategic importance that will be both proposed and debated in the context of the statutory NPF (Scottish Government, 2009c). Examples of such developments with regard to energy include electricity grid reinforcements and power stations. The latter could also theoretically include large-scale wind farms, in particular the proposals for significantly larger-scale offshore wind farms. The NPF 2 also recognises the strong spatial dimension of offshore wind in terms of the generating stations and the location of necessary supply chain and electricity transmission infrastructure.

In addition, section 26A(2) of the 2006 Planning Act gives Ministers powers to make regulations to describe classes of development other than national developments and assign each class to either major or local developments. Major developments are those projects not considered of national strategic importance but are of a size and/or scale to be considered of major importance (as such they, like the other two hierarchy 'levels' are not within the scope of the NPF). All types of electricity generating stations including fossil fuel power plants and renewable generating stations an installed capacity of 20 MW or above are designated as major developments under the Planning etc. (Scotland) Act; sub-20 MW onshore developments are designated as local developments (Scottish Government, 2009b, d). Proposals at this level (as with all levels) should be identified in the relevant local authorities' development plan, with an emphasis on prioritisation and an agreement on a timetable for the application to be determined quickly and efficiently. Local developments, making up the vast majority of the 50,000 plus planning applications decided annually, will be decided at the local level. Because many local development projects will be consistent with the relevant development plan, these should be processed quickly thus allowing more focus and resources on more controversial or complex applications, including those not in accordance with the development plan and/or the subject of significant local opinion. As with the plan-led system in England, developments that are contrary to the relevant plan are not encouraged and obtaining planning consent will be more difficult (see below). Minor developments such as domestic microgeneration projects that meet certain conditions are given deemed planning permission.[241] In addition, under the changes introduced by the Planning etc. (Scotland) Act, Scottish Ministers have the power to call-in any national or major development project to speed up decisions (Slater, 2010). The Scottish Government also decides (after consultation) on which national developments are included in the NPF. In addition, although the court acts during an appeal for national developments, Scottish Ministers can play a part in the appeal process for both major and local developments[242]. Under section 5(3) of Part III of the Planning etc. (Scotland) Act, Scottish Ministers can also direct that a particular local development is to be dealt with as if it were a major development (Scottish Government, 2006).

The result of these changes in conjunction with the capacity thresholds means that the Scottish Minister has potentially significant influence over any projects for the first three levels of the hierarchy of developments (and offshore renewable energy, see section 8.2.3.2). SPP also emphasises onshore wind by requiring that planning authorities should set out in the development plan a spatial framework for onshore

[241] Minor developments now fall within the Town and Country Planning (General Permitted Development) (Domestic Microgeneration) Scotland Amendment Order 2009.

[242] The Planning etc. (Scotland) Act 2006 introduced a Local Review Body (LRB) appeal procedure for local developments. Due to the fact that the Body is likely to comprise a group of councillors, although this will reduce costs and delays it raises concerns with respect to the effective removal of access to a truly independent arbiter for many applications: in effect the appeal is determined by those who made the original decision (Raeburn Christie Clarke & Wallace, 2009).

wind farms of 20 MW or above (major developments) and <20 MW onshore wind farms (local developments) if considered appropriate (Scottish Government, 2012b).[243] This is significant because SPP

> "*... provides a statement of the Scottish Government's policy on nationally important land use matters and reaffirms that electricity generated from renewable sources is a vital part of the response to climate change.*" (Scottish Government, 2010a: 38).

In contrast, other onshore RETs are encouraged through SPP within the context of considering environmental and other constraints. This in itself has the effect that relatively immature high-cost technologies such as solar photovoltaics and those RETS that do not fall within the microgeneration scale or are currently not yet ready for large-scale deployment will remain (potentially unnoticed) under the planning regime. This could have a particularly negative impact on the Scottish Government's aim of expanding the mix of RETs with regard to improving future diversity and security of supply, and hence helping attain RES-E targets.

The importance of this is that it could result in government imposing those projects in its interest on localities that might be against them, with particular implications for onshore wind. However, this will depend on whether Scottish Ministers refrain from involvement unless there were major objections against a project, a conflict in interest between the local authority and the development or reasons of national interest (Scottish Government, 2009e). In 2011-12, there were 53 onshore wind farm planning permission appeals received by the Directorate for Planning and Environmental Appeals (DPEA) against a previous annual average of 14.7 (Scottish Government, 2012c)[244]. In contrast there were only 2 planning permission appeals for all other RETs during the period 2004-12 (Scottish Government, 2012d). An increase in the number of onshore wind planning applications moving to appeal could be expected given the

---

[243] There are concerns that relegating sub-20MW onshore wind farm developments to the local authority level results in a failure to incorporate the national significance of such projects despite the fact that they could still have substantial negative impacts on wildlife, habitats, landscape and local communities if inappropriately designed and located.

[244] Onshore wind farm planning permission appeals: 2004-5 (10); 2005-6 (13); 2006-7 (9); 2007-8 (14); 2008-9 (14); 2009-10 (28); 2010-11 (15); 2011-12 (53) (Scottish Government, 2012c).

significant number of applications within the planning system. However, the substantial increase in 2011-12 could also arguably reflect the particular attributes and key issues of onshore wind in contrast to all other RETs. It is also suggestive of the current (political) dominance of onshore wind with regard to the Scottish RES-E sectoral target (Wood, 2010).

At the local planning authority level, the current UK Coalition Government's joint manifesto highlighted the commitment to a '*radical devolution of power*' to the local level as one of its main aims (HM Government, 2010: 11):

> "*The Government believes that it is time for a fundamental shift of power from Westminster to people. We will promote decentralisation and democratic engagement, and we will end the era of top-down government by giving new powers to local councils, communities, neighbourhoods and individuals.*"

This led ultimately to the Localism Act 2011. In particular, the Localism Act introduced Neighbourhood Plans (NP) to allow people to influence decisions and use power at local level. Although NP must have regard to national planning policy and be in general conformity with strategic policies in the local area development plan, there is concern that such a move will only act to frustrate overarching objectives including climate change and renewable energy which arguably require decisions on planning at a scale beyond that of local or indeed neighbourhood planning. This point is also relevant given that planning consent rates for onshore renewables have been significantly lower at the local authority level (<50 MW capacity) than for large-scale developments and the emphasis on the critical need for NSIP in order to meet such objectives.

Further, there is concern that limited experience and/or time will slow the formulation of NP along with financial concerns. There is also the issue that more impoverished neighbourhoods will be unlikely to participate in this decentralisation of power in comparison to wealthier areas. Section 117 of the Localism Act 2011 sets out that the costs related to neighbourhood planning will be met by the relevant communities (UK Government, 2011). This raises concerns of creating a new planning system which is not equally accessible to all communities unless they can afford to pay for qualified, impartial and reliable advice: the Department for Communities and Local Government estimates the cost of NP in the region of £5,000-250,000 each, and those communities unable to pay either lose out in participation or ask the developer to pay leading to fears over manipulation and control (FOE, 2010b) (this will be looked at in more detail in Section 8.3).

There are is also evidence that Government will not actually '*let go of the reins*' in devolving power to the local level. This links directly with the fundamental tensions inherent within planning discussed in section 8.2.2: speed versus quality; democracy versus efficiency; centralisation of priority or local priority; certainty or flexibility and consensus or conflict (Ellis, 2008).[245] As a FOE briefing clearly states: "*Historically, central government talk of devolving power tends to disguise the further centralisation of powers in Whitehall.*" (FOE, 2011c: 3). In the case of the planning system in England, although planning at the local authority level has only recently undergone significant change (primarily through the NPPF and the Localism Act 2011), the UK Government has recently introduced a number of new reforms in the Growth and Infrastructure Bill that include substantial changes to the role of local planning authorities and hence the degree of centralisation of planning power. Of particular relevance here is clause 1 of the Growth and Infrastructure Bill (2012). This creates the option for developers to by-pass local planning authorities and make an application directly to the Secretary of State

[245] As argued previously, recently reform to the planning system in both England and Scotland for major developments has been increasingly centralised. Section 7.2.3.2 also argues that marine planning is highly centralised (see page 304). Importantly, this also ties in with the increasingly dominant discourse, particularly within the UK Government, that the planning system itself is a barrier to development and hence economic growth: "*The planning system should act as a driver for growth. But if I am being completely frank with you, it's the drag anchor to growth.*" (Rt. Hon Eric Pickles, Secretary of State for Communities and Local Government speech to the Confederation of British Industry [CBI], Planning Blog, 2011: 1); "… [F]*or over a decade in this country the enemies of enterprise have had their way. So I can announce today that we are taking on the enemies of enterprise… The town hall officials who take forever with those planning decisions.*" (Rt. Hon David Cameron, Prime Minister speech to Conservative Spring Conference, New Statesman, 2011: 1). However, according to statistics released by the Department for Communities and Local Government, the time to process planning applications has fallen over the last ten years and the number of approved applications has remained around 85 per cent over that time (DCLG, 2010).

if a council has been designated by the Secretary of State as an authority which has a record of 'very poor performance'.[246]

This has a number of obvious implications for local planning authorities and renewable development and it is difficult to argue that it will address problems in the planning system at the local level: it arguably by-passes local democracy and the localism agenda, removing particular developments from contact with local people with resultant issues for public participation and engagement (communities could have a lesser and not greater say about wind energy development in their area); it centralises planning power within the UK Government and PINS in particular; the UK Government will likely face increasing numbers of planning applications for onshore wind farm developments under 50 MW (in addition to other RETs) with implications for whether or not PINS can cope with this work level in terms of staff and resources on top of recent changes to major infrastructure (see above); local planning authorities could expedite planning decisions at the cost of evidence-based decision making to improve 'performance'.

Of relevance to the above points, section 109 of the Localism Act 2011 seeks to abolish the Regional Spatial Strategies (RSS) that were put in place by the Planning and Compulsory Purchase Act 2004 (UK Government, 2004).[247] The RSS bridge the gap between local and national planning issues in England, including the setting of regional (supra-local) renewable energy targets within a strategic planning system: all nine English regions had developed policies and targets supporting renewable energy by 2009 (Ove Arup & Partners, 2009). In order to maintain coherence between national and local plans section 110 of the Localism Act 2011 introduced a legal '*duty to co-operate*' on strategic matters regarding sustainable development or land use that has or would have a significant impact on at least two planning areas in particular relating to

[246] It should be noted that the Growth and Infrastructure Bill is still going through Parliament. As such, detail is still lacking (for example, the criterion for designating an authority has having a record of very low performance with regard to planning decisions is not included currently in the Bill. Although the proposals are too recent to be included in this thesis, due to the significant implications of the Bill with regard to renewable deployment and onshore wind in particular it is worth highlighting this in brief.

[247] Section 1 of the Planning and Compulsory Purchase Act provided for the establishment of the RSS (UK Government, 2004).

major infrastructure between local authorities in order to replace the demise of the regional tier of planning (UK Government, 2011). In contrast to the RSS, however, the new mechanism does not enable regional renewable targets and loses the long-term coverage of the RSS out to 2026 (RenewablesUK, 2011). The duty to co-operate could also legitimately delay and cause uncertainty if a council or identified public body cannot agree with other areas over '*co-operative*' developments (Planning Advisory Service, 2012).

Both England and Scotland have sought to simplify guidance for developments with the aim of speeding up the planning process at the local authority level: the National Planning Policy Framework (NPPF) in England and the Scottish Planning Policy (SPP) (Department for Communities and Local Government [DCLG], 2012a). Both provide guidance that all local authorities must have regard for in drawing up local plans and making decisions on planning applications. The NPPF and SPP are therefore of importance to renewable developments with a proposed installed capacity of less than 50 MW. The reasoning behind the issue of such guidance on general and specific aspects of planning policy was to provide concise and practical guidance on planning policies in a clear and accessible form in order to inform local planning authorities about Government policy and to reduce the need for the relevant Secretary of State/Scottish Minister to utilise his powers with regard to planning appeals (Moore and Purdue, 2012). By reducing planning guidance from 1,300 pages to around 65 pages, the NPPF runs the risk of losing the practical detail and critical wording and, importantly, the *applicability* of important relevant policies (Communities and Local Government Committee [CLGC], 2011). [248] Such loss and increased vagueness introduces the potential to lose impact and credibility and result in ambiguity, increased delays and an inconsistent decision-making process (FOE, 2011d). Although the '*devil will really be in*

[248] The NPPF consolidates and replaces the majority of Planning Policy Statements (PPS), Planning Policy Guidance Notes (PPG), Mineral Planning Guidance Notes (MPG) and Circulars. The various guidance notes consolidated within the NPPF are listed in Annex 3 of the NPPF document (DCLG, 2012a). The consolidated SPP replaced the previously separate Scottish Planning Policy documents, National Planning Policy Guidance (NPPG) and some Circulars and PANs. Planning areas subsumed within the NPPF and SPP. These include diverse guidance on sustainable development, climate change, green belts, biodiversity and geological conservation, renewable energy and coastal planning. This is not a full list of such documents.

the detail' here, it is difficult to argue that this will lead to less rather than more appeals in the planning system, despite this being one of the primary aims of such guidance. The SPP faces the same risk, by relegating some of issues to planning advice notes (PANs) which do not require the same level of consultation as an SPP. In addition, there is the potential for conflict between aims in the merged SPP, for example between flooding and renewables: paragraph 207 (page 43) states "*where possible, natural features and characteristics of catchments should be restored so as to slow, reduce or otherwise manage flood waters.*" This could potentially have serious financial and locational ramifications for hydro schemes, with a resulting negative impact on the plans to expand particularly small-scale hydro (Scottish Renewables, 2010b).

In contrast to the draft NPPF, the revised version does not change the statutory status of the development plan as the starting point for decision making.[249] However, the transition period set out in the NPPF ends in March 2013: local plans that are not up to date by this deadline will be subject to the full extent of the presumption in favour of sustainable development. In other words, they will have to grant planning permission for developments unless

> "*… any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework* [the NPPF] *taken as a whole;*" (DCLG, 2012a: 4).

This will be the new decision making test on decisions on planning applications and the area for conflict and possible delays. Critically, as of April 2012, only 43 per cent of local planning authorities in England had plans adopted in conformity with the NPPF (Lainton, 2012).[250] In addition to the problems discussed above regarding the abolition of the RSS and the new 'duty to co-operate', this could result in developments being perceived to be 'forced' through, undermining the plan-led system. It could also lead to

[249] It should be pointed out that the final version of the NPPF was substantially altered from the draft version (DCLG, 2012b). The difference between the versions is not the point of this evaluation; however, where relevant, the implications deriving from such changes in policy will be examined in Section 7.5 on policy risk and uncertainty.

[250] The DCLG no longer maintains a database of plan progress in England. In terms of area, this has been calculated as equating to 42% of England being covered by such plans (Lainton, 2012).

legal challenges to the lawfulness of the NPPF presumption in favour of sustainable development (Out-law, 2012).

Although the NPPF was never intended to be issued as a 'spatial plan', there are also legitimate concerns of the impact arising from the lack of strategic of spatial planning. A spatial, strategic policy framework is a useful way to reconcile rising population and associated development needs with finite space and environmental capacity:

> "*Providing a degree of strategic oversight is particularly crucial for the natural environment which operates over wide spatial scales that will often transcend local authority boundaries.*" (RSPB, 2011: 3).

This is particularly relevant for onshore wind farms which exhibit large plant size and are sited primarily due to economic reasons based on resource quality and availability. The abolition of the regional tier of strategic planning (the RSS) will aggravate this problem and put additional pressure on the new (replacement) 'duty to co-operate' mechanism in order that the local plans together can be greater than the sum of their parts. This is important given that onshore wind is anticipated to account for a critical share of RES-E deployment out to 2020 and beyond whilst minimising conflict.

8.2.3.2 The offshore planning system in England and Scotland

The marine planning system is also undergoing extensive modernisation and reform.[251] Table 8.7 (page 315) shows the key legislation and policy for the offshore planning system in England and Scotland. The Marine and Coastal Access Act 2009 introduces a new system of marine management, including a new marine planning system, which makes provision for a statement of the UK Government's general policies, and the general policies of each of the devolved administrations for the marine environment and also for marine plans which set out in detail what is to happen in the different parts

[251] The onshore planning system does not regulate offshore development, although it is essential that development plans take into account the infrastructure and grid requirements of offshore renewable energy generation industry such as offshore wind, wave and tidal power. This is the same for all the national administrations.

Table 8.7 Key planning legislation and policy documents for offshore renewable energy installations and associated infrastructure in England and Scotland

Key legislation/policy	Information
(a) England	
Marine and Coastal Access Act 2009	Introduces a new system of marine management, including a new marine planning system, which makes provision for a statement of the UK Government's general policies, and the general policies of each of the devolved administrations for the marine environment and also for marine plans which set out in detail what is to happen in the different parts of the areas to which they relate Includes provisions changing the licensing system for activities in the marine environment and the designation of conservation zones Establishes the creation of the Marine Management Organisation (MMO) an executive Non-Departmental Public Body. The MMO will be the strategic delivery body for marine-related functions in the wasters around England and in the UK offshore area for matters that are not devolved. The MMO will license offshore energy installations with a generating capacity under 100 MW and be a statutory party to the examination of projects over 100 MW under the MIPU regime in waters in or adjacent to England and Wales Establishes a new Marine Planning System - includes Marine Policy Statement (MPS) that sets out policies for contributing to the achievement of sustainable development in the UK marine area and Marine Plans (MP) The MMO must take authorisation and enforcement decisions in accordance with the Marine Policy Statement and applicable Marine Plans unless relevant considerations indicate otherwise
(b) Scotland	
Marine and Coastal Access Act 2009	The Act provides executive devolution to Scottish Ministers of the new marine planning and conservation powers in the offshore region (12-200 nautical miles), coinciding with the existing executive devolution of marine licensing and common enforcement powers (under the Marine (Scotland) Act 2010, see below)
Marine (Scotland) Act 2010	Creates a new legislative and strategic management framework for the marine environment at the national and regional level (and more widely by working with a range of others within the UK and Europe). The main measures include a new statutory marine planning system including establishing a National Marine Plan (NMP), the delegation of marine planning functions in relation to Scottish Marine Regions (SMR), a simpler marine licensing system, marine conservation and enforcement powers To establish a National Marine Plan (NMP) - a strategic integrated framework for managing Scotland's marine environment covering both inshore waters (out to 12 nautical miles - covered by the UK Marine and Coastal Act 2009) and offshore waters (12 to 200 nautical miles) to identify major strategic projects. To identify and designate a number of Scottish Marine Regions (SMR) through secondary legislation to implement marine planning at a regional level in Scotland. Scottish Ministers would delegate planning powers to the regional level through Marine Planning Partnerships (MPPs). SMRs have to take into account the NMP and direction from Ministers under Sections 12-14 of the Marine (Scotland) Act 2010. Establishes Marine Scotland (MS), a Directorate of the Scottish Government with direct responsibility for marine science, planning, licensing, policy development, management and compliance.

SOURCES: (a) UK Government (2009a). **(b)** Scottish Government (2010b; 2012e).

of the areas to which they relate (UK Government, 2009a,b).[252] Part 3 of the Marine and Coastal Access Act 2009 established the requirement for a Marine Policy Statement (MPS) (HM Government, Northern Ireland Executive, Scottish Government and the Welsh Assembly Government, 2011). There is only one MPS for the UK marine area, jointly adopted by the Secretary of State (England), Scottish ministers, Welsh Ministers and the Department of the Environment in Northern Ireland. Published in March 2011, the MPS embodies a strategic, long-term approach to marine development in the UK marine area, and is the overarching policy framework for preparing planning in the UK marine area (EFRAC, 2011). As such, it will provide the high level policy context within which national and sub-national marine plans will be developed, implemented, monitored and amended whilst ensuring consistency across the UK marine area (HM Government, Northern Ireland Executive, Scottish Government and the Welsh Assembly Government, 2011). The Marine and Coastal Access Act 2009 requires all public authorities taking authorisation or enforcement decisions that affect (potentially or otherwise) the UK marine area to do so in accordance with the MPS unless relevant considerations indicate otherwise.

Marine planning has also been executively devolved to Scotland. The Marine and Coastal Access Act provides executive devolution to Scottish Ministers of the new marine planning and conservation and enforcement powers in the offshore region (12-200 nautical miles), coinciding with existing executive devolution of marine licensing.[253] A number of these powers are brought forward under the Marine (Scotland) Act 2010. As with the onshore system, there are a number of similarities and differences between the English and Scottish marine planning systems. The overarching policy framework for

---

[252] Previously development in the UK marine area occurred on an ad hoc, sector by sector, consent-led basis that failed to take into account the cumulative impact of decisions on the environment (Environment Food and Rural Affairs Committee [EFRAC], 2011).

[253] Key parts of the Marine and Coastal Access Act 2009 relevant to Scotland include the adopting of a Marine Policy Statement (MPS) – a framework for preparing Marine Plans and taking decisions affecting the marine environment (section 44), in particular marine planning. Jointly adopted by the Secretary of State, Scottish Ministers, Welsh Ministers and the Department of the Environment in Northern Ireland, the purpose of the MPS is to facilitate and support the formulation of Marine Plans by providing the high level policy context within which national and sub-national Marine Plans will be developed, implemented, monitored, amended in a consistent manner across the UK marine area (HM Government, 2011).

preparing planning in the UK marine area, the Marine Policy Statement is also of relevance to Scotland's marine areas (EFRAC, 2011).

Both nations have set up new bodies as the statutory strategic delivery body and regulator for marine-related functions in the relevant waters: the Marine Management Organisation (MMO) and Marine Scotland (MS) in England and Scotland, respectively. Both the MMO and MS have a number of similar powers and responsibilities. These include: implementing a new marine planning system; a new marine licensing regime; and managing a network of Marine Conservation Zones (MCZ) and European marine sites (MMO, 2012a; Scottish Government, 2010b).[254]

As with the onshore planning system, there is a capacity threshold difference between England and Scotland for offshore renewables: offshore developments with a proposed installed capacity of more than 100 MW fall under the remit of the relevant Secretary of State, in this case for DECC, whilst proposals below this threshold are designated by the MMO; in contrast, under the Electricity Act 1989 the threshold is 1 MW in Scotland. Below this, developments are designated by Marine Scotland whilst >1 MW developments are decided by the relevant Scottish Minister.

Regarding the new marine planning system in England, the MMO will be responsible for preparing the marine plans for the English inshore and offshore waters.[255] In essence, the MP will set out how the MPS will be implemented in specific areas. For England,

---

[254] The Marine (Scotland) Act also aims to streamline marine licensing by introducing a single consent license: the developer makes one application to Marine Scotland/Scottish Government for the marine license, section 36 consent and wildlife license if required, with all applications considered together in the second stage by Marine Scotland/Scottish Government before the third (final) stage where consents would be issued on approval (Scottish Government, 2009f). Prior to this a developer would apply to the Food and Environment Protection Act 1985 (Part II), the Electricity Act 1989 Section 36, the Coast protection Act 1949 and for a wildlife license where required, with applications considered separately and possibly at different timescales by the relevant bodies (second stage) before the third (final) stage of approval and consent (if the development is successful).

[255] The Marine and Coastal Access Act 2009 divide UK waters into marine regions with an inshore and offshore region under each of the four Administrations. In England, the Secretary of State is the responsible marine plan authority for both the inshore and offshore regions although power has been delegated to the MMO.

there are ten marine plans corresponding to ten inshore and offshore regions (DEFRA, 2010). This will not be a rapid process. Individual MP are expected to take around two years for completion, and although different plans can be simultaneously developed and adopted so far this has not really been the case and it is expected that full marine plan coverage will be achieved around 2021.[256] The adoption of the marine plans also represents a substantial amount of work: for example, the East Offshore area represents approximately 48,500 km^2, and although some proposed areas are significantly larger whilst others are smaller the scale of the combined MP is considerable (DEFRA, 2010). The scale of the endeavour has, however, led to concerns regarding the ability of the MMO to carry out its functions. DEFRA has cut MMO funding from £30.9 million (in 2010-11) to £24.4 million (in 2014-15) leading to fears that the organisation will not be properly funded. There is also the issue that the MPS have been specifically designed to leave a significant number of '*details*' to the individual MP level, including detailed policy and practical guidance and prioritisation. Although there is rational reasoning underlying this approach (it reflects the devolved nature of many aspects of marine policy and the devolved nature of the institutions that will deliver marine policy), in effect this loads the work onto the MP and reduces clarity between the various areas.

The main provisions of the Marine (Scotland) Act include that Scottish Ministers must prepare and adopt for the first time a National Marine Plan (NMP) for the Scottish marine area (Scottish Government, 2010b). The Act also provides the power for Scottish Ministers to decide whether or not to prepare and adopt regional marine plans or RMP (by designating Scottish Marine Regions, SMR). Covering both the inshore and offshore marine regions[257], the NMP sets out the Scottish Minister's policies for the sustainable development of the Scottish marine regions, including marine planning, licensing, conservation and enforcement and any statements or information relating to the policies contained in the plan. Both the NMP and the RMP must set out strategic

[256] The East Inshore and Offshore areas were first and second areas in England to be selected for marine planning in 2011, followed by the South Inshore and Offshore areas in November 2012 (MMO, 2012b).

[257] Therefore, the NMP is covered by both the Marine and Coastal Access Act 2009 and the Scottish (Marine) Act 2010, differentiated by inshore and offshore areas. Presumably, this will be the case for a number of RMP.

economic, social and marine environmental objectives as well as the mitigation and adaptation to climate change. Scottish Minister's can also delegate the development of RMPs to a relevant local authority or a nominated group of stakeholders (known as Marine Planning Partnerships, or MPPs). Local interests and accountability is to be ensured through regional planning, which in turn is guided by the NMP and approved by Scottish Ministers.

In addition, the NMP which was originally scheduled to be finalised in 2012 has recently been postponed until the end of 2014 (Scottish Environment LINK, 2012). The aim of the NMP was to provide forward-looking guidance to businesses seeking to develop the marine environment and ensure that marine activities develop alongside each other in a sustainable fashion. Another consequence of the delay is that the identification and designation of sensitive (environmental and historical) sites and the framework for their protection from development will also be postponed.[258] Therefore, a strategic planning vacuum lacking an overall coordinated approach will exist at the same time that offshore renewable projects are developing at a rapid pace:

> "*Unfortunately, this has the appearance of the tail wagging the dog, in this case development plans leading the national plan… without an overarching national marine plan in place, we remain in bureaucratic limbo and risk developing beyond environmental limits… Marine Protected Areas will be a critical tool to help protect and recover Scotland's marine environment. The National Marine Plan will have a role to guide developers to ensure these sites are considered across the wider marine area.*" (Scottish Environment LINK, 2012: 2).

Delaying the NMP will also in turn likely delay the establishment of Scottish Marine Regions (SMR). Through SMRs Ministers would delegate planning powers to the regional level through Marine Planning Partnerships (MPPs), and it is these partnerships that would be charged with creating appropriate RMPs. Where national marine planning sets the wider context for planning within Scotland, RMP aim to allow more local ownership and decision making about the specific issues within a smaller

[258] However, 33 Nature Conservation MPA proposals have been developed as of December 2012 and a further 4 MPA search locations remain to be fully assessed. If all these sites were designated this would account for 12% of the area of Scotland's seas. Currently, there are 46 SACs, 45 SPAs, 61 SSSIs and 8 fisheries management areas (Scottish Government, 2012f).

area but embedded within a system of regional marine plans for Scottish waters (Scottish Government, 2012g). It should also be pointed out that there is no statutory duty to implement RMPs, despite the bridging role they play between the national and local level with implications for public engagement, participation and acceptance of such developments.

The major difference between the planning system for onshore and offshore renewable developments is the degree of centralised control (Toke, 2011). Marine planning consents are highly centralised in comparison to the situation for onshore renewables for three main reasons. Offshore renewable developments with a proposed installed capacity of more than 100 MW (in England) and 1 MW (in Scotland) fall under the remit of the relevant Secretary of State/Scottish Minister, and in contrast to the early deployment of offshore wind power all but one of the new developments are in excess of the threshold and as such are designated NSIPs (Wood and Taylor, 2012).[259] Looking at current installed capacity, only 28 per cent of all offshore wind farms are 100 MW or below and thus 78 per cent fall under the control of the Secretary of State (or Scottish Minister) in comparison to 50 per cent of total onshore wind farms with an installed capacity of 50 MW or less (DECC, 2011c). The proportion will decline significantly as offshore wind deployment continues whilst the equivalent proportion for onshore wind will increase due to the increased amount of sub-50 MW developments in the planning pipeline compared to >50 MW developments. Secondly, regarding sub-100 or 1 MW developments, both the MMO and MS are not independent organisations. Despite being set up as an executive non-departmental public body (NDPB), the relevant Secretary of State (in this case for the Department for Environment, Food and Rural Affairs [DEFRA]) has significant control and influence over the MMO and thus essentially all offshore

[259] The size range (in installed capacity) for the five offshore wind Crown Estate leasing rounds are: Round 1 (awarded in 2001): 60-180 MW (only 2 out of 11 developments exceeded the capacity threshold); Round 2 (awarded in 2003): 184-1,200 MW; Round 3 (awarded in 2010): 665-12,800 MW); Round 4 or Scottish Territorial Waters Round (awarded in 2009): 450-1,800 MW; and Round 5 or Extension to Rounds 1 and 2, also called Round 2.5 (awarded in 2010): 51-750 (only 1 out of 4 developments fell below the threshold) (Wood and Taylor, 2012).

renewable deployment.[260] A Directorate of the Scottish Government, MS is arguably less 'independent' than the MMO. An additional consequence of this is that there is more centralised control over marine renewables in Scotland, not just for offshore wind (as is the case in England) but also wave and tidal stream power in the early stage of deployment given the initial small-scale developments expected in the near future. The third reason is that, again in contrast to onshore renewables and onshore wind in particular, the UK Government governs the overwhelming majority of the UK's seabed assets. The Crown Estate (CE) owns approximately 55 per cent of the UK's foreshore and virtually the UK's entire seabed from mean low water to the edge of the continental shelf and the 200 nautical mile limit (the exclusive economic zone). As such the CE plays a major role in the development of the UK offshore wind, wave and tidal stream energy industry although it is not involved in the planning consent process.

This raises concerns about the potential for a top-down imposition of offshore renewable projects (Wood and Dow, 2011). The marine planning system basically centralises power within the Government. Toke (2011) also points out that, in comparison to onshore renewables, there is increased emphasis on the strategic planning assessment of offshore renewables through Strategic Environmental Assessments (SEA). SEA is the process of appraisal through which environmental protection and sustainable development are to be evaluated and implemented into both national and local decisions at the Government and other (notably industry) plans for offshore developments, including offshore wind and marine renewable technologies. (DECC, 2012g).[261] However, criticism levelled at the England SEAs highlights the point

[260] The Secretary of State for DEFRA issues guidance and sets the overall objectives, priorities and performance indicators for the MMO. In addition, the Secretary of State's responsibilities include approving the funding of the MMO, approving a person to be appointed the Chief Executive and Chief Scientific Adviser (and their terms and conditions of employment) and appointing the Board (Marine Management Organisation [MMO], 2012b).

[261] DECC has taken a proactive stance on the use of SEA with early SEAs carried out in accordance with the European Strategic Environmental Assessment Directive (2001/42/EC) some four years prior to the directives incorporation into UK law (DECC, 2012g). There have been 8 SEAs covering the UK continental shelf, carried out between 1999 and 2009. The Scottish Government has already carried out a SEA for wave and tidal developments off the north and west coasts in 2007 and has commenced a further SEA for all Scottish waters out to the 200 nautical mile limit – see also Section 7.2.2 (RSPB, 2012b).

that the Offshore Energy SEAs (Offshore Energy SEA (2008-09) and Offshore Energy SEA2 (2011) were not spatial (RSPB, 2012b). A major problem with the SEAs

> "*... in England and Wales were that it was not spatially defined, unlike the parallel SEA in Scotland. It was so broad and shallow that it did not provide the direction for the industry in terms of where these technologies would be most appropriate spatially.*" (Huyton, 2012: 66).

In other words, there is a lack of detailed knowledge of the marine environment resulting in insufficient baseline data by which to direct developments to appropriate locations. Such an approach would have a number of benefits: avoiding damaging ecologically sensitive habitats and vulnerable bird and mammal species; reduce potential uncertainty for developers; and reduce potential conflict with environmental legislation.

The provision of sufficiently detailed baseline data on the marine environment in UK waters would aid developers by reducing both the time and unnecessary cost of carrying out analysis of potential sites in inappropriate areas. The CE offshore renewable leasing rounds mitigates some of the concerns in this respect, but the work involved in this stage does not preclude the possibility of some developments failing to obtain planning consent based on the selected offshore renewable site. Although offshore wind deployment is in the relatively early stages, in contrast to the 1,800 MW of installed capacity of offshore wind, 540 MW (or 30 per cent of the total) has been refused planning permission, at least 500 MW of capacity has been lost via down-sizing due to environmental concerns and 180 MW was withdrawn because it was going to be refused planning consent.[262] This is significant given that this loss of capacity derives directly from substantial offshore wind farms that were supposed to side-step such

[262] Docking Shoal offshore wind farm (540 MW) was refused planning consent due to environmental reasons (Centrica, 2012; Business green, 2012a). The London Array development had to cut capacity by one third (from 1.5 to 1.2 GW) over environmental (planning) concerns (Business Green, 2012b). Shell Flats (180 MW), a Round 1 offshore wind development, was withdrawn due to environmental concerns and the fact that it was going to be refused planning permission; a subsequent, smaller proposal was also cancelled due to similar fears in addition to aviation safety and radar concerns (4coffshore, 2012b). So far, around 285 MW of offshore wind capacity has been lost through down-sizing (Wood and Taylor, 2012).

constraints as planning. In addition, given the significant existing pipeline of offshore wind developments and the important contribution this RET is anticipated to make towards the RES-E target, such reductions and/or refusals will increase if these problems are not sufficiently addressed.

There is a range of legislative measures in place or in the process of development and designation to protect important marine species and habitats. These include: Ramsar sites (Convention on Wetlands); Sites of Special Scientific Interest or SSSI (Wildlife and Countryside Act 1981); Special Protection Areas or SPAs (Birds Directive); and Special Areas of Conservation or SACs (Habitats Directive). Together SPAs and SACs make up the Natura 2000 network of protected areas that form the basis of the Marine Protected Areas (MPA) in UK waters (DEFRA, 2012a).[263] Part 5 of the Marine and Coastal Access Act 2009 enables the relevant Secretary of State to designate new Marine Conservation Zones (MCZ) which will exist alongside the other protected areas to form an ecologically coherent network of Marine Protected Areas (UK Government, 2009). Currently, as MCZs are still being developed and selected, the marine protected areas network is not yet complete. Although the existing marine protected areas make a significant contribution, a number of protected species and sites are still not covered and/or sufficiently connected (DEFRA, 2012a). As DEFRA (2012b: 2) highlights: "*A key challenge in the selection of MCZs has been the weakness of the evidence base.*" In addition, although 127 MCZs were recommended in 2011 (covering 15 per cent of the English territorial waters and UK offshore waters adjacent to England, Wales and Northern Ireland), currently only 31 MCZs have been put forward for consultation with designation of the first tranche of sites expected in 2013 (DEFRA, 2012b). In addition, not one of the areas proposed where no activity would be permitted were included in the first tranche.

This leads to a cyclical problem regarding offshore renewable deployment in the England and Scotland (and indeed the UK) marine areas: the statutory Marine Plans will

---

[263] As of 2012, there are 37 inshore and 9 offshore SAC sites, 42 inshore and 1 offshore SPA sites, 113 SSSI sites and 1 MCZ site (Lundy Island) (DEFRA, 2012a).

take around a decade to be adopted and progress on adopting the statutory Marine Conservation Zones and European conservation areas (in particular the Natura 2000 sites) is slow at best and politically constrained at worst primarily due to economic issues.[264] Yet progress in both these areas is critically important if offshore renewables and offshore wind farms in particular are to be appropriately sited. This is crucial in avoiding one of the major problems of onshore wind, namely refused planning consent and public opposition.

Currently some of the biggest offshore renewable projects in the world are in various stages of development and deployment in the UK. In addition to the approximately 10 GW of offshore wind and 1.6 GW of marine renewable projects planned for Scottish waters, there are over 40 GW in the development pipeline (Wood, 2010; Wood and Taylor, 2012). In addition, a number of large-scale projects already have planning permission (Sound of Islay tidal stream array – 10 MW, the world's largest tidal stream array) or are under consideration for planning permission (Moray Firth offshore wind farm - 1.5 GW). Therefore there are a number of risks facing the development of offshore renewables: uncertainty, delays, additional costs and the potential withdrawal or refusal for developments. In addition, this could have a potentially significant impact on the public perception regarding offshore renewables, given the already high cost of offshore wind and marine RETs in particular and the high level of centralised control over planning decisions. Given the particularly high cost of wave and tidal stream devices and the critically limited real-time experience of deploying these devices in the marine environment, such issues will have a disproportionate impact on these RETs at the point in time where risk is a major factor in whether or not they will be deployed (Wood, 2010). Finally, due to the sheer amount of potential renewable generation planned to apply for planning consent, adequate funding must be made available in a timely manner to avoid increasing planning delays due to constraint in a system only

[264] The Environment Secretary Owen Paterson has been recorded as stating: "*My absolute priority, with clear instruction from the prime minister, is to do everything I can to... generate wealth and jobs in the rural economy.*" (Guardian, 2012: 1). This shows the emphasis on development over conservation in evidence in the current coalition government.

recently designed to be more streamlined. There must also be adequate resources put in place for planning to process all these renewable energy projects, especially as they are likely to apply at approximately the same time.

In contrast to the spatial approach to offshore renewables adopted in countries such as Germany and The Netherlands where developments are prohibited from specified areas (notably for environmental reasons), the UK has largely adopted a criteria-based approach (Toke, 2011). Although such an approach will again largely benefit offshore wind power, there are a number of implications arising from this: a number of offshore wind farms located in existing and/or proposed environmentally protected areas are already either operational, in construction or proposed; as stated previously, a considerable amount (in installed capacity) of offshore wind developments have already been curtailed, and maintaining the criteria-based approach will continue this trend unless due care is given. Given the average size of offshore wind farms, the loss of one or more is significant to deployment trajectories and has the potential to lead to an increase in domestic and international conflicts.

Regarding the issue, then, of the appropriate siting of offshore renewables the RSPB (2012b: 145) states that,

> "*… marine renewables can be delivered at a scale and pace in harmony with the environment, provided that the right policy framework is in place. Critical to this is reducing uncertainty for developers in the marine environment by fully designating marine protected areas… and introducing a comprehensive and transparent marine biodiversity survey in UK waters. The absence of such measures has been seen to be a major source of uncertainty and risk in the deployment of, and investment in, offshore wind.*"

Such uncertainty and risk increases the cost of deployment and offshore wind is already one of the most expensive RETs in terms of deployment. There is also the question of the potential extent of spatial overlap between existing and future offshore renewable developments and marine protected areas and other uses of the marine environment. In a DECC commissioned study into this issue, ABPmer (2011) concluded that although it is difficult to ascertain with a high level of confidence the impact of this potential conflict, management measures at a national level for all offshore renewables could be as high as £4.4 billion for the MCZ alone. The bulk of these costs would fall disproportionately on offshore wind, and include capital costs associated with relocating export and landfall point cables, habitat and species measures and associated issues regarding operation and maintenance. These findings are particularly significant due to two main reasons: costs will be focused on these sites and cable routes where such overlap occurs and therefore cost impacts will be substantially larger, leading to project delays and increased financing costs associated with the higher level of uncertainty; offshore wind has experienced very significant cost increases (see chapter seven). Yet at the same time the deployment of offshore renewables, in particular but not limited to offshore wind, is increasing rapidly in the UK and is anticipated to accelerate further to 2020 and beyond in order for the RES-E sectoral target (and climate change objectives) to be met.

References

4COffshore, 2012a. Offshore Wind Farms Database [online] Available from http://www.4coffshore.com/windfarms/default.aspx

4COffshore, 2012b. Cirrus Shall Flat Array [online] Available from http://www.4coffshore.com/windfarms/cirrus-shell-flat-array-united-kingdom-uk24.html

ABPmer, 2011. Quantifying the potential Impact of a Marine Conservation Zone (MCZ) Network on the Deployment of Offshore renewables: Report R.1763 – March 2011 – A Report for the Department of Energy and Climate Change [online] Available from http://www.gov.uk/government/uploads/systems/uploads/attachment_data/file/48172/2813-ABP-mer-mcz-report.pdf

AEA, 2010. Analysis of Renewables Growth to 2020: Report to DECC March 2010 [online] Available from http://www.decc.gov.uk/publications/basket.aspx?filepath=/assets/decc/11/meeting-energy-demand/renewable-energy/2185-analysis-of-renewables-growth-to-2020-aea-report.pdf&filetype=4&minwidth=true

Arup, 2011. Review of the generation costs and deployment potential of renewable electricity technologies in the UK: Study report REP001 Final – Updated October 2011 for the Department of Energy and Climate Change [online] Available from http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renew_obs/1834-review-costs-potential-renewable-tech.pdf

Barrow, M. 2012. What is the population of Britain? [online] Available from http://resources.woodlands-junior.kent.sch.uk/customs/questions/population.html

Bell, D., Gray, T. and Haggett, C. 2005. Policy, Participation and the Social Gap in Wind Farm Siting Decisions. *Environmental Politics* 14(4): 460-477.

Biofuelwatch, 2013. Replacing one (climate) disaster with another [online] Available from http://www.biofuelwatch.org.uk/uk-campaign/coal-biomass-conversions/

Bloomberg New Energy Finance, 2012. White Paper – UK power Forecast: Weak demand takes the bite out of the British capacity crunch – 29 February 2012 [online] Available from http://www.bnef.com/WhitePapers/download/144

British Wind Energy Association [BWEA: now Renewables UK], 2009. Wind Energy in the UK: State of the Industry Report – October 2009. BWEA, London.

Business Green, 2012a. Government green lights 1.1 GW of Norfolk offshore wind farms: race Bank and Dudgeon offshore wind farms gain planning consent, but Docking Shoal refused over bird population impact fears – 6 July 2012 [online] Available from http://www.businessgreen.com/bg/news/2189810/government-green-lights-11gw-norfolk-offshore-wind-farms

Business Green, 2012b. Red-throated divers threaten future of London Array offshore wind farm: Fate of second phase of world's largest offshore wind farm at risk from population of birds – 6 October 2011 [online] Available from http://www.businessgreen.com/bg/news/2114888/red-throated-divers-threaten-future-london-array-offshore-wind-farm

Business Green, 2012c. EDF to extend life of nuclear power plants – 4 December 2012 [online] Available from http://www.businessgreen.com/bg/news/2229396/edf-to-extend-life-of-nuclear-power-plants

Campaign to Protect Rural England [CPRE], 2011. Memorandum submitted by the Campaign to Protect Rural England – submission to the Energy and Climate Change Committee Third Report of Session 2009-10: Vol II – Ev 242 [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenergy/231/231ii.pdf

Cass, N., Walker, G. and Devine-Wright, P. 2010. Good neighbours, public relations and bribes: the politics and perceptions of community benefit provision in renewable energy development. *Journal of Environmental Policy and Planning*. 12(3): 255-275.

Centrica, 2012. Centrica receives Government consent for Race Bank wind farm – 6 July 2012 [online] Available from http://www.centrica.com/files/pdf/centrica_energy/06july2012_centrica_race_bank_wind_farm.pdf

Collar, N. Planning – 3rd Edition. Thompson Reuters (Legal) Limited.

Committee on Climate Change [CCC], 2011. Renewable Energy Review – May 2011 [online] Available from http://hmccc.s3.amazonaws.com/Renewables%20Review/The%20renewable%20energy%20review_Printout.pdf

Communities and Local Government Committee [CLGC], 2011. The National Planning Policy Framework: Eight Report of Session 2010-12 – Volume I: Report, together with formal minutes, oral and written evidence – 21 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmcomloc/1526/1526.pdf

Community Energy Online [a part of DECC], 2012. Welcome to DECC's Community Energy Online Portal [online] Available from http://ceo.decc.gov.uk/

Community Energy Scotland, 2012. Scottish Government's Community and Renewable Energy Scheme (CARES) [online] Available from http://www.communityenergyscotland.org.uk/support/cares

Crown Estate, 2012. The Crown Estate: What we do [online] Available from http://www.thecrownestate.co.uk/

Department for Communities and Local Government [DCLG], 2010. Planning authorities – planning applications received and decided by speed of decision, England [online] Available from http://www.communities.gov.uk/documents/statistics/xls/1801861.xls

Department for Communities and Local Government [DCLG], 2011. Speech: Planning reforms boost local power and growth: Joint article by the Secretary of State and the Chancellor – 4 September 2011 [online] Available from https://www.gov.uk/government/speeches/planning-reforms-boost-local-power-and-growth

Department for Communities and Local Government [DCLG], 2012a. National Planning Policy Framework - March 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

Department for Communities and Local Government [DCLG], 2012b. Government response to the Communities and Local Government Select Committee Report: National Planning Policy framework – March 2012 [online] Available from http://www.official-documents.gov.uk/document/cm83/8322/8322.pdf

Department of Energy and Climate Change [DECC], 2010. England and Wales Hydropower Resource Assessment: Final report – October 2010 [online] Available from http://www.british-hydro.org/UK%20Hydro%20Resource/England%20and%20Wales%20Resource%20Study%20Oct%202010.pdf

Department of Energy and Climate Change (DECC), 2011a. UK Renewable Energy Roadmap – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change (DECC), 2011b. National renewable Energy Action plan for the United Kingdom – Article 4 of the Renewable Energy Directive 2009/28/EC – 01/07/2010 [online] Available from http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/25-nat-ren-energy-action-plan.pdf

Department of Energy and Climate Change (DECC), 2011c. National Policy Statements for Energy Infrastructure – 19th July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/nps_en_infra/nps_en_infra.aspx

Department of Energy and Climate Change (DECC), 2011d. Overarching National Policy Statement for Energy (EN-1) – Planning for new infrastructure – July 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf

Department of Energy and Climate Change (DECC), 2011e. Updated Energy and Emissions Projections 2011: URN 11D/871 – October 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf

Department of Energy and Climate Change (DECC), 2011f. The Government response to Parliamentary Scrutiny of the Revised Draft National Policy Statements for Energy Infrastructure: Planning for new energy infrastructure – June 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/2007-govt-resp-to-parl-scrutiny-draft-nsps.pdf

Department of Energy and Climate Change [DECC], 2012a. DECC Public Attitudes Tracker – Wave 2: Summary of Key Findings [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65520/6410-decc-public-att-track-surv-wave2-summary.pdf

Department of Energy and Climate Change [DECC], 2012b. Energy Trends – September 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/6479-energy-trends-sep-2012.pdf

Department of Energy and Climate Change [DECC], 2012c. Planning database Project: Wind Onshore [online] Available from https://restats.decc.gov.uk/app/reporting/decc/monthlyextract

Department of Energy and Climate Change [DECC], 2012d. Welcome to the RESTATS Web Site [online] Available from https://restats.decc.gov.uk/cms/welcome-to-the-restats-web-site/

Department of Energy and Climate Change [DECC], 2012e. Digest of United Kingdom Energy Statistics 2012 [DUKES] [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65881/5949-dukes-2012-exc-cover.pdf

Department of Energy and Climate Change [DECC], 2012f. Gas Generation Strategy – December 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65654/7165-gas-generation-strategy.pdf

Department of Energy and Climate Change [DECC], 2012g. Strategic Environmental Assessment: What is the SEA Process? [online] Available from http://www.offshore-sea.org.uk/site/scripts/documents_info.php?categoryID=39&documentID=5

Department for Environment Food and Rural Affairs, 2010. Recommended marine plan areas for the English Inshore and English Offshore Marine Regions – July 2010 [online] Available from http://webarchive.nationalarchives.gov.uk/20101109165532/http://www.defra.gov.uk/corporate/consult/marine-plan/marine-plan-recommended-areas.pdf

Department for Environment Food and Rural Affairs, 2012a. Report to Parliament on the Marine Protected Areas Network – December 2012 [online] Available from http://www.defra.gov.uk/publications/files/pb13856-marine-protected-areas.pdf

Department for Environment Food and Rural Affairs, 2012b. Marine Conservation Zones: About MCZs [online] Available from http://archive.defra.gov.uk/environment/marine/documents/protected/20121217-mcz-factsheet-about.pdf

Department of Trade and Industry, 2007. Meeting the Energy Challenge – A White Paper on Energy – May 2007 [online] Available from http://www.berr.gov.uk/files/file39387.pdf

Devine-Wright, P. 2010. Public Engagement with large-scale renewable energy technologies: breaking the cycle of NIMBYism. Wiley Interdisciplinary Reviews: Climate Change 2(1): 19-26.

Devine-Wright, P. 2011. Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

DRAX Group Plc, 2012. About DRAX's biomass plans [online] Available from http://www.draxgroup.plc.uk/biomass/cofiring_plans/

Ecorys, 2010. Assessment of non-cost barriers to renewable energy growth in EU Member States – AEON: DG TREN No. TREN/D1/48 – 2008: Final Report for DG Energy and Transport [online] Available from http://ec.europa.eu/energy/renewables/studies/doc/renewables/2010_non_cost_barriers.pdf

Edge, G. 2006. A Harsh Environment: The Non-Fossil Fuel Obligation and the UK Renewables Industry, in K. Mallon (ed), Renewable Energy Policy and Politics: A handbook for decision-making: 163-184. Earthscan.

EDF, 2012. Our nuclear power stations [online] Available from http://www.edfenergy.com/about-us/energy-generation/nuclear-generation/nuclear-power-stations/

Eggborough Power, 2013. Welcome to Eggborough Power [online] Available from http://www.eggboroughpower.co.uk/

Electricity Networks Strategy Group [ENSG], 2009. ENSG 'Our Electricity Transmission Network: A Vision for 2020' Full Report [online] Available from http://www.ensg.gov.uk/assets/ensg_transmission_pwg_full_report_final_issue_1.pdf

Ellis, G. 2008. Wind power and the "planning problem" – ESRC/ISW Seminar: 4th November 2008 Queen's University, Belfast [online] Available from http://iws.rgu.ac.uk/abs/research/page.cfm?pge=75708

Ellis, G., Cowell, R., Warren, C., Strachan, P., Szarka, J., Hadwin, R., Miner, P., Wolsink, M. and Nadaï, A. 2009. Wind Power: Is There A "Planning Problem"? Expanding Wind Power: A Problem of Planning, or of Perception? The Problems Of Planning—A Developer's Perspective Wind Farms: More Respectful and Open Debate Needed, Not Less Planning: Problem "Carrier" or Problem "Source"? "Innovative" Wind Power Planning. *Planning Theory & Practice* 10(4): 521-54.

Energy and Climate Change Committee [ECCC], 2011. The revised draft National Policy Statements on energy: Report, together with formal minutes, oral and written evidence – Third Report of Session 2010-11 – 26 January 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201011/cmselect/cmenergy/648/648.pdf

Energy and Climate Change Committee [ECCC], 2012. The Future of Marine Renewables in the UK: Eleventh Report of Session 2010-12: Volume I: Report, together with formal minutes, oral and written evidence – 19 February 2012 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1624/1624.pdf

Energy Savings Trust, 2012. Community and locally owned renewable energy in Scotland – June 2011: A report by the Energy Saving trust for the Scottish Government – Final Report [online] Available from http://www.energysavingtrust.org.uk/scotland/Publications2/Communities/Community-and-locally-owned-renewable-energy-PDF

Engineering the Future Alliance, 2011. The Future of Marine Renewables: Response from the Engineering the Future Alliance to the Energy and Climate Change committee – September 2011 [online] Available from http://www.raeng.org.uk/societygov/policy/responses/pdf/EtF_ECC_marine_renweables_response.pdf

Environment Food and Rural Affairs Committee [EFRAC], 2011. The Marine Policy Statement: Second Report of Session 2010-11: Report, together with formal minutes, oral and written evidence – 28 January 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201011/cmselect/cmenvfru/635/635.pdf

E.ON, 2013. Ironbridge [online] Available from http://www.eon-uk.com/generation/ironbridge.aspx

European Wind Energy Association [EWEA], 2009. Pure Power: Wind energy targets for 2020 and 2030 – 2009 update [online] Available from European Wind Energy Association [EWEA], 2009. Pure Power: Wind energy targets for 2020 and 2030 – 2009 update

European Wind Energy Association [EWEA], 2012. The European offshore wind industry key 2011 trends and statistics: January 2012 – A report by the European Wind Energy Association [online] Available from http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_stats_offshore_2011_02.pdf

Forth Energy, 2012. Woodfuel [online] Available from http://www.forthenergy.co.uk/biomass.asp

Friends of the Earth [FOE], 2010a. The Planning Act 2008: January 2010 Briefing [online] Available from http://www.foe.co.uk/resource/briefings/planningact2008.pdf

Friends of the Earth [FOE], 2010b. Briefing: The Localism Act – December 2010 [online] Available from http://www.foe.co.uk/resource/briefing_notes/localism_bill.pdf

Friends of the Earth [FOE], 2011a. Energy from biomass: Straw Man or Future Fuel? May 2011 Briefing [online] Available from http://www.foe.co.uk/resource/briefings/energy_biomass.pdf

Friends of the Earth [FOE], 2011b. Briefing 5: England's power shift: localism and all that… - September 2011 [online] Available from http://www.foe.co.uk/resource/briefing_notes/englands_powershift_4_loca.pdf

Friends of the Earth, 2011c. Draft National Planning Framework: Development at any cost? October 2011 [online] Available from http://www.foe.co.uk/resource/briefings/draft_nppf_development_at.pdf

Friends of the Earth [FOE], 2012. The English Planning System: An overview – September 2012 Briefing [online] Available from http://www.foe.co.uk/resource/guides/31_the_english_planning_sy.pdf

Greenpeace, 2007. Decentralising Power: An Energy revolution for the 21st Century [online] Available from http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7154.pdf

Guardian, 2012. UK seas to gain 31 marine conservation zones: campaigners dismayed that ministers rejected advice to create 127 zones, which are intended to protect ocean floors – 13 December 2012 [online] Available from http://www.guardian.co.uk/environment/2012/dec/13/uk-marine-conservation-zones

HM Government, 2007. Planning for a Sustainable Future – White Paper: May 2007 [online] Available from http://www.official-documents.gov.uk/document/cm71/7120/7120.pdf

HM Government, 2010. The Coalition: our programme for government [online] Available from http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_187876.pdf

HM Government, 2011. UK Marine Policy Statement: HM Government, Northern Ireland Executive, Scottish Government, Welsh Assembly Government – March 2011 [online] Available from http://www.scotland.gov.uk/Resource/Doc/295194/0115242.pdf

HM Government, Northern Ireland Executive, Scottish Government and the Welsh Assembly Government, 2011. UK Marine Policy Statement – March 2011 [online] Available from http://www.defra.gov.uk/publications/files/pb3654-marine-policy-statement-110316.pdf

House of Commons Library, 2012. Major Infrastructure Planning: Standard Note: SN/SC/5041 – 17 May 2012: Author: Christopher Barclay [online] Available from http://www.parliament.uk/briefing-papers/SN05041

Huyton, H. 2012. The Future of Marine Renewables in the UK: Inquiry of the Energy and Climate Change Committee [ECCC] – Evidence – Tuesday 13 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1624/1624.pdf

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008a. Renewable electricity generation technologies – Volume I – Fifth Report of Session 2007-08 – 11 June 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/cmdius.htm

Innovations, Universities, Science and Skills Committee [IUSS Committee], 2008b. Renewable electricity generation technologies – Government Response to the Committee's Fifth Report of Session 2007-08: Eight Special Report of Session 2007-08 – 8 October 2008 [online] Available from http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/1063/1063.pdf

Institute for the Study of Science Technology and Innovation, 2010. Wind Power Planning and Public Engagement: Challenges and Opportunities – ISSTI Briefing Note (Number 8) May 2010 [online] Available from http://www.esrc.ac.uk/my-esrc/grants/PTA-026-27-2236/outputs/read/ff93246f-d919-4d72-8a29-aec565adc7e2

International Renewable Energy Agency [IRENA], 2012. IRENA Policy Brief: Evaluating Policies in Support of the Deployment of Renewable Power [online] Available from http://www.irena.org/DocumentDownloads/Publications/Evaluating_policies_in_support_of_the_deployment_of_renewable_power.pdf

Jamasb, T., Nuttall, W.J., Pollitt, M.G. and Maratou, A., 2008. Technologies for a low-carbon electricity system: an assessment of the UK's issues and options, in: Grubb, M., Jamasb, T. and

Jones, C.R. and Eiser, R. 2010. Understanding 'local' opposition to wind development in the UK: How big is a backyard? Energy Policy 18(2010): 3106-3117.

Lainton, A. 2012. My adopted Local Plan Database made Public #NPPF – April 12 2012 [online] Available from http://andrewlainton.wordpress.com/2012/04/12/my-adopted-local-plan-database-made-public-nppf/

Loring, J.M. 2007. Wind energy planning in England, Wales and Denmark: Factors influencing project success. Energy Policy 35(2007): 2648-2660.

Marine Management Organisation [MMO], 2012a. About us [online] Available from http://www.marinemanagement.org.uk/about/index.htm

Marine Management Organisation [MMO], 2012b. Her Majesty's Government and the Marine Management Organisation: Framework Document 2012 [online] Available from http://www.marinemanagement.org.uk/about/documents/mmo-framework.pdf

Marinenet, 2012. 90% of investment in London Array windfarm is from abroad – 29/12/2012 [online] Available from http://www.marinet.org.uk/90-of-investment-in-london-array-windfarm-is-from-abroad.html

Mitchell, C. 1995. The renewables NFFO: A review. Energy Policy 23(12): 1077-1091.

Mitchell, C. and Connor, P. 2004. Renewable energy policy in the UK 1990-2003. Energy Policy: 32: 1935-1947.

Moore, V. and Purdue, M. 2012. A Practical Approach to Planning Law – Twelfth Edition. Oxford University press: Oxford.

Munday, M., Bristow, G. and Cowell, R. 2011. Wind farms in rural areas: How far do community benefits from wind farms represent a local economic development opportunity? Journal of Rural Studies 27(2011): 1-12.

Nadaï and van der Horst, 2009. Editorial: Wind power planning, landscapes and publics. Land Use Policy 27(2010): 181-184.

National Audit Office [NAO], 2008. Renewable energy: Options for scrutiny – A Review by the National Audit Office – July 2008 [online] Available from http://www.nao.org.uk/publications/0708/renewable_energy_options.aspx

National Audit Office [NAO], 2010. The Electricity generating Landscape in Great Britain – Briefing for the House of Commons Energy and Climate Change Committee – July 2010 [online] Available from

National Planning Forum, 2009. Fit for purpose spatial planning: proposals from the National Planning Forum – October 2009 [online] Available from http://www.natplanforum.org.uk/NPF%20Fit%20for%20purpose%20spatial%20planning.pdf

New Statesman, 2011. Full Transcript| David Cameron| Speech to Conservative Spring Conference| Cardiff| 6 March 2011 [online] Available from http://www.newstatesman.com/2011/03/enterprise-government-party

Nolden, C. 2012. Regulating energy security through the diffusion of innovation – A community perspective [online] Available from http://www.exeter.ac.uk/energysecurity/documents/ese_resources_May2012/Colin_Nolden.pdf

Office of Gas and Electricity Market Regulation [OFGEM], 2011. The Retail market review – Findings and initial proposals: Consultation 34/11 – 21 March 2011 [online] Available from http://www.ofgem.gov.uk/Markets/RetMkts/rmr/Documents1/RMR_FINAL.pdf

Office of Gas and Electricity Market Regulation [OFGEM], 2012. Feed-in Tariff Update: Issue 10 – December 2012 – Ofgem E-Serve [online] Available from http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/Feed-in%20Tariff%20Update%20Quarterly%20Report%20Issue%2010.pdf

Office of the Deputy prime Minister, 2005. Planning Policy Statement 1: Delivering Sustainable Development [online] Available from http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&ved=0CDUQFjAA&url=http%3A%2F%2Fwww.birmingham.gov.uk%2Fcs%2FSatellite%3Fblobcol%3Durldata%26blobheader%3Dapplication%252Fpdf%26blobheadername1%3DContent-Disposition%26blobkey%3Did%26blobtable%3DMungoBlobs%26blobwhere%3D1223391850647%26ssbinary%3Dtrue%26blobheadervalue1%3Dattachment%253B%2Bfilename%253D217970Planning_Policy_Statement_1.pdf&ei=M-7-UOyNOILM0QXypoCIDQ&usg=AFQjCNE8f59aHWIccZdGh1SD7wgUBkI3rQ&bvm=bv.41248874,d.d2k

Offshore Wind Cost Reduction Task Force, 2012. Offshore Wind Cost Reduction Task Force Report – June 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66776/5584-offshore-wind-cost-reduction-task-force-report.pdf

Out-law, 2012. 2013 will be the year when the NPPF really bites, says expert [online] Available from http://www.out-law.com/en/articles/2012/december/2013-will-be-the-year-when-the-nppf-really-bites-says-expert/

Ove Arup & Partners, 2009. Renewable Energy Capacity in Regional Spatial Strategies: Final Report – July 2009: Report for the Department for Communities and Local Government [online] Available from http://www.uea.ac.uk/~e680/energy/energy_links/renewables_Obligation/renewableenergyreport.pdf

Palmer, J. 2005. Hydro Power Projections Study [online] Available from http://www.uea.ac.uk/~e680/energy/Old_modules/env2e02/individual_reports/Group_d/hydro.pdf

Parliament and Constitution Centre, 2003. An introduction to devolution in the UK – Research Paper 03/84: 17 November 2003 [online] Available from http://www.parliament.uk/documents/commons/lib/research/rp2003/rp03-084.pdf

Pasqualetti, M.J. 2011. Social Barriers to Renewable Energy Landscapes. The Geographical review 101(2): 201-223.

Planning Advisory Service, 2012. A simple guide to Strategic Planning and the 'Duty to Co-operate' [online] Available from http://www.pas.gov.uk/pas/core/page.do?pageId=2133454#contents-5

Planning Blog, 2011. Pickles woos CBI – Tuesday 22 March 2011 [online] Available from http://planningblog.planningresource.co.uk/2011/03/22/pickles-woos-cbi/

Planning Democracy, 2012. Re-valuing public participation in Scotland's planning system: A planning democracy advocacy paper – Discussion draft – April 2012 [online] Available from http://www.planningdemocracy.org.uk/resources/PAP_discuss_draft_web_April12.pdf

Planning Help, 2012. Planning for Major Infrastructure Projects [online] Available from http://www.planninghelp.org.uk/planning-explained/planning-for-major-infrastructure-projects/the-consultation-process

Pollitt, M.G. (Eds), Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy. Cambridge University Press: Cambridge.

Raeburn Christie Clark & Wallace, 2009. Planning etc (Scotland) Act 2006 [online] Available from http://www.raeburns.co.uk/Uploads/Publications/PlanningAct_Nov2009.pdf

Reid, C.T. 2009. Nature Conservation Law: 3rd edition. Thompson Reuters: London.

Renewable Energy Foundation [REF], 2012. Energy Data [online] Available from http://www.ref.org.uk/energy-data

Renewable UK, 2011. Written evidence submitted by RenewableUK (LOCO 087) – Ev 202: Response to the Communities and Local Government Committee Third Report of Session 2010-12: Localism – Volume II: Additional written evidence – 7 June 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmcomloc/547/547vw.pdf

Renewable UK, 2012. The voice of wind and Marine Energy [online] Available from http://www.renewableuk.com/

Ricardo-AEA, 2012. Who We Are [online] Available from http://www.ricardo-aea.com/cms/

Royal Society for the Protection of Birds [RSPB], 2009. Positive Planning for Onshore Wind: Expanding onshore wind energy capacity while conserving nature – A Report by the Institute for European Environmental Policy Commissioned by the Royal Society for the Protection of Birds: March 2009 [online] Available from http://www.rspb.org.uk/Images/Positive%20Planning%20for%20Onshore%20Wind_tcm9-213280.pdf

Royal Society for the Protection of Birds [RSPB], 2011a. A response from the RSPB to the consultation on the draft National Planning Policy Framework – October 2011 [online] Available from http://www.rspb.org.uk/Images/draftnppfconsultation_tcm9-292794.pdf

Royal Society for the Protection of Birds [RSPB], 2011b. RSPB Scotland response: Inquiry into the Scottish Government's Renewable Energy Targets by the Economy, Energy and Tourism Committee [online] Available from http://www.rspb.org.uk/Images/Inquiry_into_Energy_Targets_tcm9-311613.pdf

Royal Society for the Protection of Birds [RSPB], 2012a. Dirtier than coal? Why Government plans to subsidise burning trees are bad news for the planet [online] Available from http://www.rspb.org.uk/Images/biomass_report_tcm9-326672.pdf

Royal Society for the Protection of Birds [RSPB], 2012b. Memorandum submitted by RSPB – Ev 104: Response to the Energy and Climate Change Committee [ECCC] Eleventh Report of Session 2010-12: The Future of Marine Renewables in the UK – Vol I: Report, together with formal minutes, oral and written evidence – 19 February 2012 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1624/1624.pdf

RWE npower, 2012. Tilbury Power Station [online] Available from http://www.rwe.com/web/cms/en/97606/rwe-npower/about-us/our-businesses/power-generation/tilbury/

Scottish Environment LINK, 2012. National Marine Plan delay threatens sustainability agenda: Press release: 11 October 2012 [online] Available from http://www.scotlink.org/files/policy/PressReleases/PRNMPdelyaOct12.pdf

Scottish Government, 2002. The Electricity Act 1989 (Requirement of Consent for Offshore generating Stations) (Scotland) Order 2002: 2002 No. 407 Electricity – Scottish Statutory Instruments [online] Available from http://www.legislation.gov.uk/ssi/2002/407/pdfs/ssi_20020407_en.pdf

Scottish Government, 2005. White Paper on Planning – Modernising the Planning System [online] Available from http://www.scotland.gov.uk/Publications/2005/06/27113519/35231

Scottish Government, 2006. Planning etc. (Scotland) Act [online] Available from http://www.legislation.gov.uk/asp/2006/17/pdfs/asp_20060017_en.pdf

Scottish Government, 2007. The Blacklaw renewable Energy Fund [online] Available from http://www.scotland.gov.uk/Publications/2007/10/09113958/32

Scottish Government, 2008. Scottish Hydropower Resource Study: Final Report – 2008 [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0064958.pdf

Scottish Government, 2009a. Town and Country Planning (Scotland) Act 1997 [online] Available from http://www.legislation.gov.uk/ukpga/1997/8/section/277

Scottish Government, 2009b. Scottish Planning Series Circular 5 2009: Hierarchy of Developments – July 2009 [online] Available from http://www.scotland.gov.uk/Publications/2009/07/03153122/1

Scottish Government, 2009c. National planning Framework for Scotland [online] Available from http://www.scotland.gov.uk/Topics/Built-Environment/planning/National-Planning-Policy/npf/Q/editmode/on/forceupdate/on

Scottish Government, 2009d. The Town and Country Planning (Hierarchy of Developments) (Scotland) Regulations 2009: Town and Country Planning 2009 No. 51 – Scottish Statutory Instruments [online] Available from http://www.legislation.gov.uk/ssi/2009/51/pdfs/ssi_20090051_en.pdf

Scottish Government, 2009e. Scottish planning Series: Planning Circular 3 2009: Notification of Planning Applications: Scottish Ministers' role in planning applications – March 2009 [online] Available from http://www.scotland.gov.uk/Publications/2009/03/27112705/2

Scottish Government, 2009f. Marine (Scotland) Bill [online] Available from http://www.scottish.parliament.uk/s3/bills/25-MarineScot/b25bs3-aspassed.pdf

Scottish Government, 2010a. Scottish Planning Policy – February 2010 [online] Available from http://www.scotland.gov.uk/Resource/Doc/300760/0093908.pdf

Scottish Government, 2010b. Marine (Scotland) Act [online] Available from http://www.legislation.gov.uk/asp/2010/5/pdfs/asp_20100005_en.pdf

Scottish Government, 2011a. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011b. The Electricity Act 1989 (Requirement of Consent for Hydro-electric Generating Stations) (Scotland) revocation Order 2011: 2011 No. 115 Electricity - Statutory Instruments [online] Available from http://www.legislation.gov.uk/ssi/2011/115/pdfs/ssi_20110115_en.pdf

Scottish Government, 2011c. Raising the threshold for consent on onshore hydro schemes: Scottish Government Response – February 2011 [online] Available from http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/17851-1/HydroS36Thresholds/S36SG

Scottish Government, 2012a. Onshore Wind turbines Information – October 24 2012 [online] Available from http://www.scotland.gov.uk/Resource/0040/00405870.pdf

Scottish Government, 2012b. Process for preparing spatial frameworks for wind farms – last updated August 2012 [online] Available from http://www.scotland.gov.uk/Resource/0040/00400726.pdf

Scottish Government, 2012c. Review of the Year 2011-2012 – August 2012 – Directorate for planning and Environmental Appeals [online] Available from http://www.scotland.gov.uk/Resource/0040/00401025.pdf

Scottish Government, 2012d. Annual Reviews – Directorate for Planning and Environmental Appeals [online] Available from http://www.scotland.gov.uk/Topics/Built-Environment/planning/Appeals/ourperformance/annualreviews

Scottish Government, 2012e. Marine Planning and Legislation [online] Available from http://www.scotland.gov.uk/Topics/marine/seamanagement

Scottish Government, 2012f. Report to the Scottish parliament on progress to identify a Scottish Network of Marine Protected Areas – Marine Scotland – 2012 [online] Available from http://www.scotland.gov.uk/Resource/0041/00410766.pdf

Scottish Government, 2012g. Regional Planning [online] Available from http://www.scotland.gov.uk/Topics/marine/seamanagement/regional

Scottish Power, 2013. End Of An Era for Cockenzie Power Station – 45 Years of Electricity Generation Comes To A Close – 15 March 2013 [online] Available from http://www.scottishpower.com/PressReleases_2502.htm

Scottish Renewables, 2010a. Driving the Low Carbon Economy: Paper 5 – Planning – 7 December 2010 [online] Available from http://www.scottishrenewables.com/publications/driving-low-carbon-economy-paper-5-planning/

Scottish Renewables, 2010b. Scottish Planning Policy Proposed Changes Consultation: Response from Scottish renewables and BWEA [online] Available from http://www.scottishrenewables.com/Default.aspx?DocumentID=5a1ee546-3869-4062-af06-f785c8ee1054

Scottish Renewables, 2012a. Scottish Renewables Planning Briefing: Planning to enable Scotland's renewable energy ambitions – 24 January 2012 [online] Available from http://www.scottishrenewables.com/publications/scottish-renewables-planning-briefing/

Scottish Renewables, 2012b. Scottish Renewables response to the Scottish Government consultation on Development Delivery – 3 July 2012 [online] Available from http://www.scottishrenewables.com/publications/scottish-renewables-development-delivery/

Scottish renewables, 2012c. Scotland's Renewable Energy Sector in Numbers [online] Available from http://www.scottishrenewables.com/scottish-renewable-energy-statistics-glance/

Scrase, I. 2011. Revised Draft national policy Statements for Energy Infrastructure Response to Consultation – January 2011: Response by the Royal Society for the Protection of Birds [RSPB] [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenergy/231/231ii.pdf

Semple Fraser, 2005. Modernising the Planning System – 19 July 2005 [online] Available from http://www.semplefraser.co.uk/a/ModernisingPlanning

Sheate, W., Eales, R., Baker, J., Stafford, J., Barker, A., van Der Burgt, N. and Rosário Partidário, 2011. A Natural Planning Framework: Putting the Natural Environment at the Heart of the National Planning Framework for England: Final Report for the RSPB by Collingwood Environmental Planning Ltd – January 2011 [online] Available from http://www.rspb.org.uk/Images/RSPB_NPF_report_2_tcm9-270015.pdf

Simpson, A. and Read, G. 2011. Written evidence submitted by Alan Simpson and Gerard Read – Submission to the House of Commons Energy and Climate Change and Environmental Audit Committee Inquiry into Solar Power Feed-in Tariffs: Vol II – 22 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1605/1605vw.pdf

Slater, A.M. 2010. Law Essentials: Planning Law. Dundee University Press: Dundee

Strachan, P. 2012. Submission from Professor Peter A. Strachan - Evidence to the Economy Energy and Tourism Committee Inquiry into Renewable Energy (Targets) [online] Available from http://www.nuclearconsult.com/docs/consultation/ScottishGovernmentSubmission_ProfStrachan.pdf

Strachan, P. and Jones, D. 2012. Navigating a minefield? Wind power and local community benefit funds, in: Szarka, J., Cowell, R., Ellis, G., Strachan, P. and Warren, C. (eds) Wind Power Society and Governance: Lessons for Future Sustainable Energy. Palgrave.

The Planning Inspectorate, 2012. National Infrastructure Planning: National Policy Statements – What are National Policy Statements? [online] Available from http://infrastructure.planningportal.gov.uk/legislation-and-advice/national-policy-statements/

Toke, D. 2005. Explaining wind power planning outcomes: Some findings from a study in England and Wales. Energy Policy 33(12): 1527-1539.

Toke, D. 2011. The UK offshore wind power programme: A sea-change in UK energy policy? Energy Policy (39): 526-534.

Toke, D. and van der Horst, D. 2010. Exploring the landscape of wind farm developments: local area characteristics and planning process outcomes in rural England. Land Use Policy 27(2010): 214-221.

Toke, D., Breukers, S. and Wolsink, M. 2008. Wind power deployment outcomes: How can we account for the differences? Renewable and Sustainable Energy reviews 12(2008): 1129-1147.

Troen, L. and Peterson, E.L. 1989. European Wind Atlas. Risø National Laboratory, Roskilde, 656pp. [online] Available from http://www.windatlas.dk/europe/About.html

UK Energy Research Council [UKERC], 2010. Great Expectations: The cost of offshore wind in UK waters – understanding the past and projecting the future – September 2010 [online] Available from http://www.ukerc.ac.uk/support/tiki-download_file.php?fileId=1164

UK Government, 1989. The Electricity Act 1989 [online] Available from www.legislation.gov.uk/ukpga/1989/29/contents

UK Government, 1990a. Town and Country Planning Act 1990 [online] Available from http://www.legislation.gov.uk/ukpga/1990/8/contents

UK Government, 1990b. The Electricity Act 1989 (Requirement of Consent for Hydro-electric Generating Stations) (Scotland) Order 1990: 1990 No. 392 (S.41) – Statutory Instruments [online] Available from http://www.legislation.gov.uk/uksi/1990/392/made

UK Government, 2004. Planning and Compulsory Purchase Act 2004 – Chapter 5 [online] Available from http://www.legislation.gov.uk/ukpga/2004/5/pdfs/ukpga_20040005_en.pdf

UK Government, 2008. Planning Act 2008 [online] Available from http://www.legislation.gov.uk/ukpga/2008/29/contents

UK Government, 2009a. The Marine and Coastal Act 2009 [online] Available from http://www.legislation.gov.uk/ukpga/2009/23/contents

UK Government, 2009b. The Marine and Coastal Act 2009 – Explanatory Notes [online] Available from http://www.legislation.gov.uk/ukpga/2009/23/notes

UK Government, 2011. Localism Act 2011 [online] Available from http://www.legislation.gov.uk/ukpga/2011/20/pdfs/ukpga_20110020_en.pdf

Walker, G. and Cass, N. 2011. Public roles and socio-technical configurations: Diversity in renewable energy deployment in the UK and its implications, in: Devine-Wright, P (Ed), Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

Walker and Devine-Wright, 2008. Community renewable energy: what should it mean? Energy Policy 36(2): 497-500.

Walker, G., Devine-Wright, P. and Evans, B. 2005. UK Community Energies: Database. Community Energy Initiatives [online] Available from http://www.geography.lancs.ac.uk/cei/Community EnergyUKProjects.htm

Walker, G., Devine-Wright, P., Barnett, J., Burningham, K., Cass, N., Barton, J., Evans, B., Heath, Y., Infield, D., Parks, J. and Theobald, K. 2011. Symmetries, Expectations, Dynamics and Contexts: A framework for Understanding Public Engagement with Renewable Energy Projects, in: Devine-Wright, P (Ed), Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

Warren, C. and McFadyen, M. 2008. Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland – ESRC/ISW Seminar: 4th November 2008 Queen's University, Belfast [online] Available from http://iws.rgu.ac.uk/abs/research/page.cfm?pge=75708

Warren, C. and McFadyen, M. 2010. Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. Land Use Policy 27(2010): 204-213.

Watson, J., Scrase, I. and Stapleton, L. 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables Target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Welsh Government, 2012. Planning [online] Available from http://www.wales.gov.uk/topics/planning/?lang=en

Wolsink, M. 2007. Wind power implementations: The nature of public attitudes: Equity and fairness instead of 'backyard motives'. Renewable and Sustainable Energy Reviews 11(2007): 1188-1207.

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee.

Wood, G. and Dow, S. 2011. *What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy*. Energy Policy 39(2011): 2228-2244.

Wood, G. and Taylor, A. 2012. Offshore Wind - A Position paper: A Report for the Offshore Renewables Institute – December 2012.

Woodman, B. 2008. Connecting the future: the UK's renewable energy strategy – A report by Dr Bridget Woodman of the University of Exeter: Commissioned by Greenpeace – September 2008 [online] Available from http://www.greenpeace.org.uk/files/pdfs/climate/connectingthefuture.pdf

Woodman, B. and Mitchell, C. 2011. *Learning from experience? The development of the Renewables Obligation in England and Wales 2002-2010*. Energy Policy 39(2011): 3914-3921.

YouGov, 2011. YouGov/Sunday Times Survey Results – 2011 [online] Available from http://cdn.yougov.com/cumulus_uploads/document/gm4jg0973n/Sunday%20Times%20Results%20111125%20VI%20and%20Trackers.pdf

8.3 Public participation and engagement

So far, public participation and engagement has been examined with regard to the internal failures (chapter seven) and the planning system (chapter eight, Section 8.2). This has focused on the issues and barriers related to the structures of opportunity to participate in the process: in other words, how does the type and design of the subsidy mechanism and planning legislation and policy facilitate and encourage public participation and engagement in the process?[265] An equally valid question that forms the focus of this section is: in which ways can or does public participation and engagement improve the decision making process and acceptance of such developments. Just as important is how these two spheres interact. This has a number of implications for renewable deployment across the UK.

As discussed previously, renewable electricity technologies are a varying technical category in terms of form with very different attributes. They can be deployed at a wide range of scales: from the micro to the large industrialised scale. In addition, again in contrast to low carbon and fossil fuel technologies, renewable technologies exhibit a broad range of geographic dispersal, individual plant size and landscape impact (see Table 4.2). RET deployment can be located both close to/within urban areas and increasingly remote, as urban-industrial developments, rural installations or deep within the non-industrial, undeveloped natural landscape. As Walker and Cass (2011: 46) state:

> "*It then becomes increasingly difficult to generalize about the interaction of technologies with types of place/spaces, as their relational qualities can be quite distinct.*"

Increasingly, public participation and engagement is viewed as critical with regard to the deployment of RETs at all scales. There are a number of key reasons for encouraging

---

[265] Public participation and engagement will also be examined with regard to the remaining external failures: Electricity networks (chapter eight, section 8.4) and Policy risk/uncertainty (section 8.5).

public participation and engagement regarding renewable energy. Wright (2011: 701) points out the fundamental importance of public participation and engagement:

> "*If we do not have the public on board, I do not think that the targets are achievable… The same is true with planning: we will not see a higher consent rate without public support… That is too high a hurdle to overcome if we want to build the infrastructure quickly. It reflects high uncertainty among the public about projects that impinge on their local environment.*"

This is important. Although the focus has been on wind power in general and onshore wind in particular, most new developments require some level of public acceptance, with a concomitant role for engagement and participation in the process by members of the public.[266] There are implications for those living or interacting in some way with these new facilities and significant deployment is required to meet statutory targets (Cowall *et al*., 2012).

Focusing on large-scale renewables (>5 MW installed capacity), one scale of particular relevance to the issue of public acceptance and engagement is the medium-sized or meso-scale, generally defined as having an installed capacity of between 5-50MW. Although there are uncertainties regarding the meaning of meso-scale (see below), this scale of deployment has been argued to be more acceptable to the public. Additionally, it has been argued to be more suitable for communities, co-operatives and small (energy) companies and organisations including local authorities, farmers and individuals; termed community energy, this is the project scale that these groups can typically be involved, particularly in terms of bringing forward deployment. This has the potential to play an important role in RES-E deployment in the UK. As such, community and locally-owned renewable electricity projects will be the focus of this section.

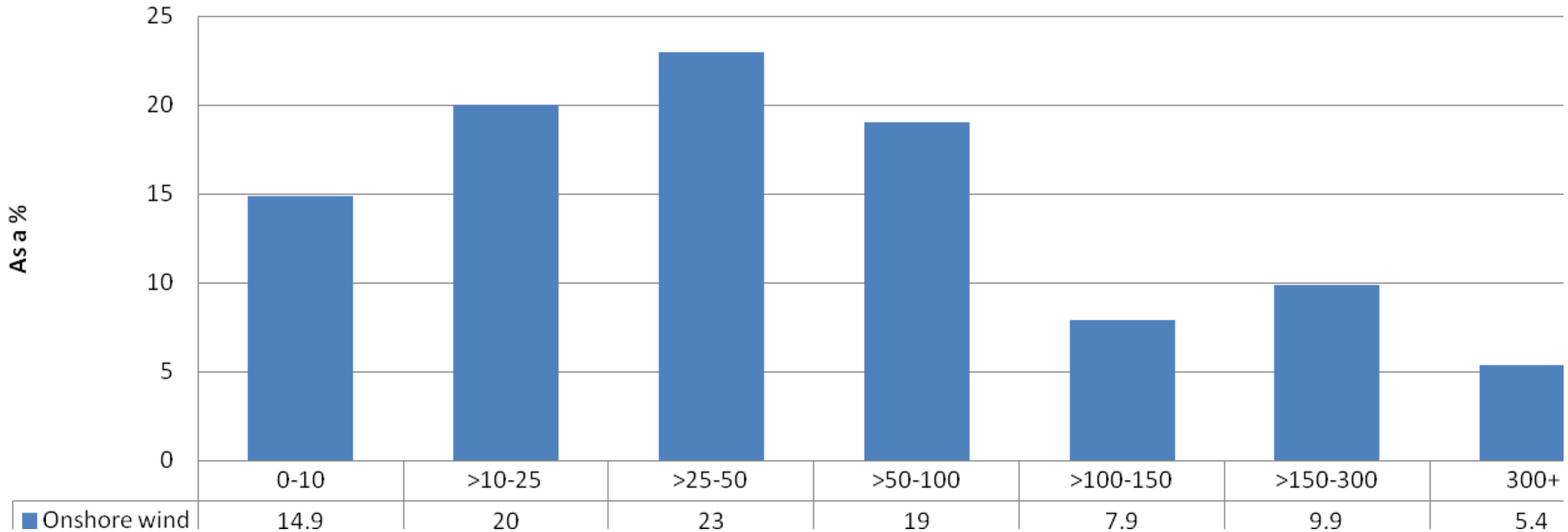
[266] The focus on onshore wind, however, might more accurately reflect the scale of current deployment levels (both annual and cumulative) for this technology over recent years. A number of other RETS can and do face similar difficulties, particularly at the planning stage, for example biomass and waste technologies.

8.3.1 Meso-Scale Deployment and Community Renewable Projects

Although meso-scale or medium-sized energy projects are clearly defined as consisting of developments with an installed capacity of between 5-50MW, a number of uncertainties exist around the actual meaning of the term, particularly with regard to community energy. Firstly, the scale appears to be somewhat arbitrary: there is a significant difference in scale between 5MW and 50MW; also, it is unclear what the difference is between a 45MW meso-scale and a 55 MW large-scale onshore wind farm. Secondly, meso-scale deployment is typically conflated with the term '*local energy*' which can imply a number of meanings: energy generation occurs locally (but is the output used locally or fed into the national electricity grid?); developments at this scale can be termed '*local*' with regard to the impacts particularly on the surrounding landscape and communities; that establishing a deployment locally results in social and economic benefits accruing to that community or communities.

Currently no consensus exists in the extant literature on the definition of community or locally-owned energy: such a project can be wholly or partially-owned with non-local companies and organisations out-with the community, including multinationals and utilities. This leads to the issue of community involvement and to what extent local communities are involved in the project in question and in terms of public engagement and participation in the decision-making process (for example, where the development will be located; number and position of turbines; community benefits). Any discussion on this subject, therefore, needs to clarify and define what type of project is actually being examined.

Graphically highlighting the size distribution of onshore wind farms in the UK as of August 2013, Figure 8.3 (page 349) shows that over half (58 percent, or 7,444 MW installed capacity) of all onshore wind either operational, under construction or awaiting construction falls into the sub-50 MW installed capacity category. Deployment can be further disaggregated: 15 percent (1,911 MW) is 0-10 MW; 20 percent (2,594 MW) is >10-25 MW; and 23 percent (2,939 MW) are >25-50 MW. In comparison, there is just 42 percent (5,386 MW) of projects >50 MW installed capacity. In terms of



Size range	0-10	>10-25	>25-50	>50-100	>100-150	>150-300	300
MW	1,911	2,594	2,939	2,400	1,011	1,282	693

Figure 8.3 Size distribution of onshore wind farms in the UK as of August 2013 as a percentage and installed capacity (MW)

Note: Data adapted from Renewable UK Wind Energy Database - UKWED (Renewable UK, 2013). Data includes wind farms operational, under construction, awaiting construction, under appeal and approved on appeal or judicial review.

installed capacity, there is also more sub-50 MW projects in the process of applying for planning determination than for >50 MW (see Table 8.2).

In contrast, it is impossible to clarify the scope of community and locally-owned renewable deployment in the UK. Currently no such database exists.[267] The reports that do exist provide conflicting levels of deployment; indicate problems with data collection (incomplete, inaccurate and/or double-count data), whether or not the technology is used to generate electricity or heat and/or do not separate data for <5 (small-scale FIT) and >5 MW (RO) projects. Estimates at the UK level range from: 60 MW at the UK level (ResPublica, 2013); 26.5 MW (Office of Gas and Electricity Markets [OFGEM], 2012); +1.2 GW (Co-operatives, 2012). The most complete database exists for Scotland. In contrast to the UK, Scotland has an up-to-date database (Energy Saving Trust, 2012).[268] As of the end of June 2011, Scotland has 147 MW of community and locally owned renewable projects; of this 64 MW is electricity capacity (or 163 GWh of electricity generation output) with 57 MW from onshore wind power. At the Scottish level, there are a further 666 MW in the development pipeline (under construction/consented but not built/in planning/in scope). This data is not broken down into heat or electricity and 205 MW (or 31 per cent) is due to the Shetland Charitable Trust's portion of the Viking wind farm (Energy Savings Trust, 2012).

Looking at projections of future community renewable projects, ResPublica (2013) estimate that there is around 5.27 GW of renewable electricity technology potential capacity in the UK. This is a significant potential contribution to the RES-E sectoral target, equating to around 13 to 15 per cent of the total installed capacity required to meet the UK sectoral target.

---

[267] There is one online database but dates from 2005 and therefore is non-representative of the current situation for community renewable projects (Walker *et al.*, 2005).The only accessible data is for the FIT (<5 MW) mechanism: out of a total installed capacity of 1,487 MW (September 2012), only 3% or 14.87 MW is categorised as community owned. The vast majority was domestic (90%), followed by non-domestic commercial (26%) and non-domestic industrial (3%) (OFGEM, 2012).

[268] Both the target and the database are broken down into: community based projects, other public sector and charity, farms and estates, local businesses, local authorities and housing associations (Energy Saving Trust, 2012).

8.3.2 The Opportunities and Barriers for Public Participation and Engagement

Haggett (2011) points out that public participation and engagement can be used to more actively involve the public in the process and through their input not only potentially reduce conflict in decision making but also facilitate the appropriate siting of a renewable development. Local people may be '*local*' experts, and this allows access to a detailed and contextualised knowledge of the local area into the planning process that would otherwise likely be inaccessible to developers and planning authorities. Members of the public also inherently deserve the right to actively participate in the planning system in order to improve accountability, transparency and democracy (Devine-Wright, 2011).

There are also a number of further advantages from emphasising public participation and engagement in planning, with particular emphasis at the community or locally-owned scale. Increasingly acknowledged and accepted, such advantages include reduced environmental impacts[269] (locally-sourced supplies, reduced transportation), development of local skills, the alleviation of fuel poverty, building supply chains, employment and industrial growth at the local level particularly in rural areas and grid issues with emphasis on off-grid applications again in rural or non-grid areas. (DECC, 2012; Greenpeace, 2007; Watson et al., 2010). The potential for reduction in conflicts is also advantageous for developers in terms of both time and costs.[270] Community and locally-owned energy projects can increase local engagement and promote behavioural change with regard to energy use, conservation and reduction local leadership, greater accountability and/or control and increased ownership. These benefits can only improve issues of local democracy. Local communities can also benefit from the location of a meso-scale energy project in their area by gaining direct access via some form of ownership (partial, full) to the subsidised revenue streams on offer rather than through the significantly reduced financial revenue via '*community benefits*' or similar alternative offer including reduced energy bills (see below).

---

[269] This would be in addition to reducing greenhouse gas emissions.

[270] It is important to stress that whilst these benefits exist, this is not always realised in reality.

However, it is currently unclear if and to what extent non-community and locally-owned projects provide such additional benefits (except with regard to the high-level objectives including climate change and energy security). One point is clear: community ownership is central to what could be termed a cultural shift whereby the behavioural patterns of communities and people are changed from consumers to active energy producers through increased responsibility, participation and engagement. It is clear that not all of these advantages can be allocated to >50 MW (or larger industrialised projects).[271] This also highlights the ownership of power generation in the UK. The '*Big Six*' large-scale multi-national companies dominate both electricity supply (99 per cent) and total power station capacity (72 per cent) in the UK (FOE, 2011b; Office for Gas and Electricity Markets [OFGEM], 2011). For onshore wind, that figure for capacity rises to 47 per cent and around 64 per cent for offshore wind power, the latter figure reflecting the scale and costs involved that are prohibitive to smaller companies (Centrica, 2012; EDF Energy Renewables, 2012; E.ON, 2012; Renewable Energy Association [REA], 2012; Renewable UK, 2013; RWE npower, 2012; Scottish and Southern Energy [SSE], 2012; Scottish Power, 2012). Regarding onshore wind, there are a number of other companies that although not vertically reintegrated like the '*Big Six*' own a significant proportion of capacity: combined, the Big Six and the eleven next largest companies, each with over 100 MW installed capacity (a number of them multi-national and/or located abroad) account for 73 percent of onshore installed capacity (Renewable UK, 2013).[272] The remainder comes from smaller companies. Although there is uncertainty regarding the amount of community and locally-owned developments, it is highly likely that they account for around 1 percent of total deployment.

---

[271] Such large-scale renewable energy deployments typically exhibit larger environmental footprints (however, both negative and positive in terms of potential GHG emission reductions, for example) and grid issues in terms of requiring new or upgraded capacity (Wood, 2010).

[272] The 'Big Six' account for 7,838 MW of installed capacity out of a total of 12,968 MW operational, under construction, awaiting construction or with planning consent: SSE (1,792MW); RWE npower (1,006MW); Scottish Power/Iberdrola (1,572MW); E.ON (1,114MW); EDF (576MW); Centrica has no onshore wind capacity. The eleven non-vertically integrated companies are: Vattenfall (445MW); RES (679MW); Ecotricity (160MW); Fred Olsen (418MW); Community Windpower (337MW); Infinis (261MW); Banks Developments (150MW); Falck Renewables (289MW); Infinergy (299MW); Peel Energy (173MW); Beinn Mhol Power (140MW) (Renewable UK, 2013).

As can be seen from the level of ownership, typically a high proportion of the equipment and expertise comes from these companies which are generally based abroad.[273] This can impact on local supply chain growth and wider economic benefits and has implications for onshore wind development in rural areas where economic development outcomes surrounding such deployment to date have been questionable. Regarding offshore wind, around 90 per cent of the £1.5 billion cost of the 630MW London Array offshore wind farm went to foreign supply chain companies whilst the 180 MW Robin Rigg offshore wind farm obtained 32 per cent of UK content (Marinet, 2012).

This leads to a critical question: do community based projects (ranging from community-owned to mixed community-developer based models) result in increased levels of *ex-ante* support for not only such projects but importantly for larger-scale and/or developer-based developments? And does this expedite the planning process? Currently there exists only a small amount of research examining the influences of different development models on attitudes to wind farms, namely community based contra developer-based projects. Warren and McFadyen (2010: 209) showed that the promotion of a 'more locally embedded approach to wind farms' (community-owned) can help reduce the incidence of damaging conflicts which affects onshore wind deployment in the UK and help facilitate the achievement of renewable energy targets:

> "*… community ownership is indeed associated with positive attitudes to wind farms, but support for wind power is not low in Kintyre* [the developer based project in comparison to the community-based project at Gigha]*… Arguably the most significant finding concerns the positive influence of ownership on the attitudes of communities towards wind energy projects, a finding which supports the long-held supposition that a change of development model could increase public support for windfarms in Scotland and other parts of the UK.*"

As stated above, there is some evidence to suggest that community ownership changes opinions about development although this requires further examination. In addition, this benefit in terms of both ownership and increased public participation and

[273] For example, of the 'Big Six' energy companies only SSE is a British-owned company. In addition, a number of the other companies are based abroad: Vattenfall (Sweden); Falck Renewables (Italy).

engagement is recognised by the UK Government. The '*UK Renewable Energy Roadmap*' states

> "*Projects are generally more likely to succeed if they have broad public support and the consent of local communities. This means giving communities both a say and a stake, in appropriately-sited renewable energy projects like windfarms.*" (DECC, 2011: 35).

Importantly, this leads to a number of additional questions that remain currently unanswered: to what extent does an increasing proportion of community or locally-owned energy projects increase the acceptance of non-community or locally-owned projects amongst the public in general? This is particularly relevant for large-scale deployments (Cass *et* al., 2010; Cowell *et al*., 2011; Strachan and Jones, 2012; Warren and McFadyen, 2010). Perhaps an additional question to be considered here is the potential impact of such projects on planning decision-making. In other words, do such projects increase the chance of a project gaining planning consent? It would also be relevant to examine whether local acceptance equates to obtaining planning consent.

These issues are highly relevant when looking at medium-scale energy projects as purely comprising developments of 5-50 MW installed capacity, analysing the REPD database provides interesting results on approval rates (in terms of installed capacity) for <50 MW projects: during the period 2007-12, there is a decreasing trend overall during the period 2007 to 2012 at the UK level and for Scotland and England. Although Scotland shows a decline from 74% in 2007 to 52% in 2012, approval rates in England exhibit a more substantial decline from 72% to 29% over the same time period. At the UK level, approval rates dropped from 74% to 48%. In contrast, approval rates over the same period were significantly higher for >50 MW projects at the UK, England and Scotland level. Without looking at the individual planning applications, it is difficult to determine the reasons for the decline in approval rates over this period, although issues of community will feature strongly in the decisions made given that <50 MW developments are determined at the local planning authority and not central government.[274]

This also highlights the issue of different deployment and ownership models: community and developer-based models arguably lie at opposing ends of the spectrum (Walker and Devine-Wright, 2008). In between, however, are a rich variety of options, combining elements and advantages of both: for example, the community of Fintry (Stirlingshire) owns one turbine of a nearby commercial wind farm (Warren and McFadyen, 2010). As can also be seen from the above quote, meso-scale renewable deployment also plays a role in not only increasing public acceptance and engagement but also in the diffusion of knowledge of, and an awareness and understanding of renewable energy technologies (Nolden, 2012).

The principle of public participation and engagement is widely recognised but people face significant disadvantages when trying to engage with the planning system (Planning Democracy, 2012). The major thrust of the recent planning reforms in both England and Scotland focus on streamlining and speeding up the planning decision-making process for large-scale developments (see Section 7.2); in general there has been very little concomitant effort for developments that fall under local planning authority jurisdiction and for community and locally-owned projects in particular. Critically, as with the subsidy system (the RO, see Chapter Six), the planning system does not take into account meso-scale deployment: the capacity thresholds (whether set under the Planning Act 2008 in England and Wales or the Electricity Act 1989 in Scotland) are either below 50 MW or above 50 MW.[275] There is no in-between and no community or locally-owned-specific provisions despite the difficulties inherent at this stage (see below).[276] The Coalition UK Government has clearly stated that it would

[274] There are of course differences between England and Scotland due in large part to the divergence in planning system increasing over time since devolution in 1997 (see Section 8.2). In addition, the Scottish Executive has also been arguably more vociferous and consistently supportive of renewable and onshore wind deployment in particular than in England.

[275] This is also true with regard to the electricity network in the UK (see section 8.4).

[276] For example, planning applications for community renewable generation projects in Denmark, Germany and the Netherlands are often processed within three months. The reasons for this include: clearer rules and varying levels of community ownership are built in as preconditions. The advantages of

promote the radical devolution of power and greater financial autonomy to local government and community groups in large part via reform to the planning regime and the localism agenda, there has been very little progress in reforming the planning system with regard to community or locally-owned renewables. This is despite the visionary pledge in the Coalition Manifesto (HM Government, 2010:17) to

> "*… encourage community-owned renewable energy schemes where local people will benefit from the power produced.*"

The NPPF, the cornerstone of sub-50MW developments in England, fails to mention public participation and engagement; indeed, there is only a rather weak provision regarding community renewable schemes:

> "*In determining planning applications, local planning authorities should expect new development to …support community-led initiatives for renewable and low carbon energy.*" (Communities and Local Government Committee [CLGC], 2011: 22).

In contrast, the SPP states that

> "*Effective* [community] *engagement with the public can lead to better plans, better decisions and more satisfactory outcomes and can help avoid delays in the planning process. It also improves confidence in the fairness of the planning system.*" (Scottish Government, 2010a: 5).[277]

Indeed, one of the key actions of the 2020 Routemap is to "*… lead the way in terms of supporting community ownership of renewables.*" (Scottish Government, 2011b: 24).

---

this approach can be seen by the fact that around 20% of Germany's 60GW of renewable installed capacity is owned by large-scale typically ex-utility energy companies: the rest is owned by communities, development trusts, farmers and households (Simpson and Read, 2011).

[277] This is backed-up by '*PAN 81: Community Engagement*' and the '*2020 Routemap for Renewable Energy in Scotland*' which set a target for community and locally-owned renewable energy for Scotland (see below) (Scottish Government, 2007b; Scottish Government, 2011). PAN 81 essentially looks at improving awareness and engagement in the planning process with emphasis on early engagement at both central and local levels. However, it fails to mention community and locally-owned renewable schemes and avoids proposing concrete definitions of terms including consultation, engagement, involvement and participation.

The benefits of community and locally-owned developments, however, are not reflected in the planning decision-making process. The planning system also does not take into account the difference between public consultation and public participation: the former is generally where members of the public are asked their opinion on carefully chosen questions in contrast to public participation, where members of the public are actively empowered to make decisions. A consequence of this disregard is the limited devolution of control to the public which in turn constrains the building of trust between developers and people (Institute for the Study of Science Technology and Innovation, 2010). Additionally, although both the English and Scottish planning systems permit the involvement of third parties, neither system allows third party right of appeal. This is significant. It raises the question of who should be allowed to participate and engage and constrains people from doing so on the arbitrary basis of location. There is also an intrinsic imbalance between developers and the public in terms of expertise, time, awareness of the process, costs, transparency and access to information and lack of recognition of the value from public participation (Planning Democracy, 2012). Placing significant limitations on the ability of the public to participate properly in the planning system, such an imbalance will also disproportionately impact on poorer communities with the result of further feelings of disenfranchisement.

This will be aggravated by the move towards the front-loading of the planning process. In recent years, the planning system in England and Scotland has emphasised the role of greater inclusivity. Both the Planning Act 2008 and the Planning etc Scotland Act 2006 have introduced statutory requirements to engage with local communities, local planning authorities and those people/organisations directly affected by the project at the pre-application stage prior to the submission of the actual planning application.[278] It is correct to involve all participants, particularly local communities, as early as possible. In addition, such an approach could allow members of the public to influence the way projects are developed, how they are integrated into the community; obtain important information and an understanding of the development and critically, to

[278] Provisions for pre-application consultation (PAC) are found in Part 5 Chapter 2 of the Planning Act 2008 and Part 3(11)35(A)-(C) of the Planning etc Scotland Act 2006; in Scotland these procedures came into force from 3 August 2009 (Scottish Government, 2006; UK Government, 2008).

permit the early mitigation of measures via identifying problems prior to the official planning submission stage (Department for Communities and Local Government [DCLG], 2012).

However, pre-application consultation is only a legal requirement for Nationally Significant Infrastructure Projects in England (>50 MW) and National (projects considered of long-term national significance) and Major (including >20MW onshore wind farms) Projects in Scotland (Scottish Government, 2006; UK Government, 2008). There is no such requirement for <50 MW projects in England or Local developments in Scotland, despite the impact that such developments can and do have. There is also valid concern regarding the incorporation of pre-consultation as a key element in front-loading the system: it is the applicant or developer that will be the sole provider of a one way source of information ('*information provision*') concerning the proposed development to the public (Haggett, 2011). Importantly, the inclusivity of the consultation process is also dependent on the developer in question. The '*Guidance for pre-application consultation*' states that

> "*However, it is for the applicant to satisfy themselves that their consultation plan allows for as full public involvement as is appropriate for their project… Provided that applicants can satisfy themselves… it would be unlikely that their application would be rejected on grounds of inadequate public consultation.*" (DCLG, 2012: 10-11).

In other words, there is very little government (or independent) control over the pre-application consultation process. In contrast, planning authorities in Scotland will be responsible for checking the effectiveness of the pre-application consultation report and have the power to refuse to register the planning application if deemed inadequate (Scottish Government, 2010a)

In addition, this approach results in respondents being forced to reply to existing proposals and as such does not reflect true participation and engagement where communities actively become involved in decisions such as location, type of technology and number of turbines. In other words, there is no consensus-building. This approach also runs the risk introducing a strong element of bias with regard to the type and presentation of information; such pre-consultation is unlikely to build trust between developers and the public and will also normally involve abstract discussions of future developments that are by no means certain to go ahead in reality. Adding further pressure on time, costs and access to information (including an awareness of events), this raises the question of why communities should really get involved at that stage and whether they have the resources, given the intrinsic limitations mentioned above.

There is also the difference in emphasis for this scale of development by the UK government and the National Administrations. As can be seen, there has been no concrete initiatives so far at the UK overall level. In contrast, Scotland has been more proactive. The Scottish Government has led the way with a number of initiatives: establishing in June 2011 a non-legally binding target of 500 MW of community and locally-owned renewable energy by 2020 (Scottish Government, 2011); the Community and Renewable Energy Loan Scheme (CARES) to support projects before they reach the planning stage (those projects considered too high risk for commercial loans). Individual projects can receive loans of up to £150,000 and free legal advice and support. CARES is open to community organisations, rural businesses and joint ventures between the two (Community Energy Scotland, 2012). At the UK level, however, the Chancellor announced in autumn 2012 a £15 million fund (the Rural Community Renewable Energy Fund, run jointly by DECC and DEFRA) to meet the upfront cost of developing renewable projects. These funds are in addition to various documents and toolkits provided by various governments to support community renewable developments (Community Energy Online [a part of DECC], 2012).[279]

However, the efforts discussed here fail to address the fundamental barriers to community and locally-owned renewable electricity projects, including subsidy levels, planning, grid (see Section 8.4) and policy risk (see Section 8.5). Although the benefits of such a scale of development outweigh installed capacity and as such the target is

[279] At the UK overall level the Department of Energy and Climate Change (DECC) published a consultation to explore the issue of community engagement and benefits for onshore wind in September 2012. In addition, DECC is currently preparing a Community Energy Strategy for publication in late autumn 2013.

commendable, when examined alongside the Scottish RES-E target which requires around 16-17,000 MW of renewable electricity capacity, the 500MW target is insignificant: 2.9 to 3.1 percent of the target. This is particularly the case when measured against the legally-binding UK target of 35-40 GW: 1.1 to 1.4 percent.

8.3.3 Community Benefits: An Alternative Approach to Securing Public Support

Aside from the opportunities within the planning systems and the advantages of public participation and engagement, there is another route used on the basis that it could potentially increase public participation and engagement in the planning process: '*community benefits*'.[280] These are voluntary agreements between the developer and local communities and as such are out with the planning system. There is no specified type or level of community benefit as such details are left to the agreement and depend on the community(s) and developer in question. The benefit is typically set as £/MW of installed capacity per annum (Cowall *et al*., 2011). Originating from the growing conflict over the siting of onshore wind developments near to where people live or visit, community benefits are the provision of financial (or material) benefits by developers to the area affected by the infrastructure.

There are a number of objectives behind this approach, including to foster social acceptance, good neighbourliness and compensation. The underlying rationale is to somehow increase the social acceptability of wind farm development via a form of trade off. As the '*2020 Routemap for Renewable Energy in Scotland*' (Scottish Government, 2011: 59) states:

[280] Community benefits are distinct from Planning Conditions (PC) and Planning Obligations (PO): Almost all planning permissions that are granted are subject to conditions. PCs may be imposed not over the question of whether the development should be permitted at all but on what terms it should be permitted, but to enhance the quality of the development and mitigate any adverse effects from the development being permitted (Moore and Purdue, 2012). PCs are typically site-specific. In contrast, POs are generally used to secure wider benefits from the development. Both have a statutory basis in planning law in both England (called '*Section 106*' of the Town and Country Planning Act 1990) and Scotland(called '*Section 75*' of the Town and Country Act 1997) (Slater, 2010). Planning Obligations can be used for a variety of purposes including removing obstacles to a planning permission occurring, providing infrastructure and providing for long term after-care and to re-instate the landscape. However, POs can be used to provide a legal basis for community benefit agreements (Scottish Government, 2007b).

> "*... community benefits and the scope for local ownership of energy are key elements of public engagement in renewables, helping to change cultural attitudes to renewables as well as to generate local revenue as part of the green low carbon economy.*"

In practice, however, in contrast to community ownership

> "*The available evidence indicates that* [community benefits] *are only playing a small part in winning wider community acceptance of wind power, and further in helping developers secure planning consent. Indeed, the available evidence indicates that the current system within which community benefit provision is agreed is actually acting as an additional source of tension, and this is likely to continue.*" (Strachan, 2012: 3).

There is concern that community benefits assume that opposition can be explained by localised, individual self-interest: in a sense, the impact of the deployment can be somehow bought off. This leads to claims that the planning process is being brought into disrepute (Ellis *et al*., 2009).

There are additional issues of concern with the provision of community benefits. It is not an alternative to the issues of local (community) ownership or the active empowerment of such communities in the planning and decision making process. As such, it is contra the findings of the research by Warren and McFadyen (2010). As Bell *et al* (2005: 175) state:

> "*The benefits of community ownership may have as much to do with local involvement in the development process as they do with the potential profits of ownership.*"

Such benefits are also arguably a poor alternative to communities owning renewable technologies and directly receiving the relevant subsidy stream from the Renewables Obligation mechanism. In addition, it fails to encourage communities to be not just consumers but energy producers. This highlights the difference between the rapid deployment of onshore wind in Denmark and Germany from the 1990s: the proportion of community and locally-owned developments is significantly higher than in the UK.[281] This was due to the adoption of a feed-in tariff as the financial subsidy mechanism in these two countries enabling a lower level of entrants into the renewable market (communities and local people) by reducing investment risk via the guarantee of a fixed subsidy level in addition to reduced costs in accessing the electricity transmission and distribution network and a simplified planning system focusing on this scale of renewable technology deployment (Energy and Climate Change and Environmental Audit Committees, 2011). The main point, then, is that such lower level entrants could control the terms on which wind farm development took place. It is revealing that Devine-Wright (2010) shows that in the UK active public participation and engagement is only promoted at smaller scales in contrast to a more passive role promoted at larger scales.

However, the key reason why it is unlikely that community scale renewables will not make a significant contribution to the target is that deployment is dominated by large-scale companies that do not need community involvement to any great extent (Warren and McFadyen, 2010). Despite this, the value of community and locally-owned renewable deployment should not be under-estimated as the potential advantages could significantly out-weigh the level of installed capacity that is realised.

[281] In Denmark, around 80% of all onshore wind turbines are community owned (Committee on Climate Change [CCC], 2011). For Germany, the proportion is around 50% (Energy and Climate Change and Environmental Audit Committees, 2011).

References

Bell, D., Gray, T. and Haggett, C. 2005. Policy, Participation and the Social Gap in Wind Farm Siting Decisions. *Environmental Politics* 14(4): 460-477.

Camco and Baker Tilley, 2011. The potential for the GIB to support community renewables: A report for the Co-operative Group – Reference no: P003421: Final draft [online] Available from http://www.vercoglobal.com/images/uploads/insights-reports/GIBsupportforcommunityrenewables_FINAL_1379.pdf

Cass, N., Walker, G. and Devine-Wright, P. 2010. Good neighbours, public relations and bribes: the politics and perceptions of community benefit provision in renewable energy development. *Journal of Environmental Policy and Planning*. 12(3): 255-275.

Centrica, 2012. Renewables [online] Available from http://www.centrica.com/index.asp?pageid=984#ourProjects

Committee on Climate Change [CCC], 2011. The Renewable Energy review – May 2011 [online] Available from http://hmccc.s3.amazonaws.com/Renewables%20Review/The%20renewable%20energy%20review_Printout.pdf

Communities and Local Government Committee [CLGC], 2011. The National Planning Policy Framework: Eight Report of Session 2010-12 – Volume I: Report, together with formal minutes, oral and written evidence – 21 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmcomloc/1526/1526.pdf

Community Energy Online [a part of DECC], 2012. Welcome to DECC's Community Energy Online Portal [online] Available from http://ceo.decc.gov.uk/

Community Energy Scotland, 2012. Scottish Government's Community and Renewable Energy Scheme (CARES) [online] Available from http://www.communityenergyscotland.org.uk/support/cares

Co-operatives UK, 2012. Manifesto for a community energy revolution: Part of the work of the Community Energy Coalition [online] Available from http://www.uk.coop/energymanifesto

Cowell, R., Bristow, G. and Munday, M. 2011. Acceptance, acceptability and environmental justice: the role of community benefits in wind energy development. *Journal of Environmental Planning and Management* 54(4): 539-557.

Cowell, R., Bristow, G. and Munday, M. 2012. Wind energy and justice for disadvantaged communities: Viewpoint – May 2012: A report for the Joseph Rowntree Foundation [online] Available from http://www.jrf.org.uk/sites/files/jrf/wind-farms-communities-summary.pdf

Department for Communities and Local Government [DCLG], 2012. Planning Act 2008: Guidance on the pre-application process [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/49468/Planning_Act_2008_pre-applications.pdf

Department of Energy and Climate Change [DECC], 2011. UK Renewable Energy Roadmap – July 2011 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48128/2167-uk-renewable-energy-roadmap.pdf

Department of Energy and Climate Change [DECC], 2012. Onshore Wind – Call for Evidence: Part A – Community Engagement and Benefits – 20 September 2012 [online] Available from http://www.decc.gov.uk/assets/decc/11/consultation/wind/6437-onshore-wind-call-for-evidence-document-part-a-com.pdf

Devine-Wright, P. 2010. Public Engagement with large-scale renewable energy technologies: breaking the cycle of NIMBYism. Wiley Interdisciplinary Reviews: Climate Change 2(1): 19-26.

Devine-Wright, P. 2011. Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

EDF Energy renewables, 2012. Projects [online] Available from http://www.edf-er.com/Projects/index.htm

Energy and Climate Change and Environmental Audit Committees, 2011. Solar Power feed-in Tariffs: Volume II: Additional written evidence – 14 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1605/1605vw.pdf

Energy Savings Trust, 2012. Community and locally owned renewable energy in Scotland – June 2011: A report by the Energy Saving trust for the Scottish Government – Final Report [online] Available from http://www.energysavingtrust.org.uk/scotland/Publications2/Communities/Community-and-locally-owned-renewable-energy-PDF

E.ON, 2012. Onshore [online] Available from http://www.eon-uk.com/generation/onshore.aspx

Friends of the Earth [FOE], 2011a. Successful Planning: Putting social, environmental and economic objectives at the heart of the planning system [online] Available from http://www.foe.co.uk/resource/briefings/successful_planning.pdf

Friends of the Earth [FOE], 2011b. The Dirty half Dozen: Report – October 2011 [online] Available from http://www.foe.co.uk/resource/reports/dirty_half_dozen.pdf

Greenpeace, 2007. Decentralising Power: An Energy revolution for the 21st Century [online] Available from http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7154.pdf

Haggett, C. 2008. The social acceptance of wind energy: Current thinking and implications for the future – ESRC/ISW Seminar: 4th November 2008 Queen's University, Belfast [online] Available from http://iws.rgu.ac.uk/abs/research/page.cfm?pge=75708

Haggett, C. 2010. Understanding public responses to offshore wind power. Energy Policy 39(2): 503-510.

Haggett, C. 2011. 'Planning and Persuasion': Public Engagement in Renewable Energy Decision-Making, in: Devine-Wright, P (Ed), Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

Institute for the Study of Science Technology and Innovation, 2010. Wind Power Planning and Public Engagement: Challenges and Opportunities – ISSTI Briefing Note (Number 8) May 2010 [online] Available from http://www.esrc.ac.uk/my-esrc/grants/PTA-026-27-2236/outputs/read/ff93246f-d919-4d72-8a29-aec565adc7e2

Marinenet, 2012. 90% of investment in London Array windfarm is from abroad – 29/12/2012 [online] Available from http://www.marinet.org.uk/90-of-investment-in-london-array-windfarm-is-from-abroad.html

Moore, V. and Purdue, M. 2012. A Practical Approach to Planning Law – Twelfth Edition. Oxford University press: Oxford.

Nolden, C. 2012. Regulating energy security through the diffusion of innovation – A community perspective [online] Available from http://www.exeter.ac.uk/energysecurity/documents/ese_resources_May2012/Colin_Nolden.pdf

Office of Gas and Electricity Market Regulation [OFGEM], 2011. The Retail market review – Findings and initial proposals: Consultation 34/11 – 21 March 2011 [online] Available from http://www.ofgem.gov.uk/Markets/RetMkts/rmr/Documents1/RMR_FINAL.pdf

Office of Gas and Electricity Market Regulation [OFGEM], 2012. Feed-in Tariff Reports [online] Available from https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/feed-tariff-reports

Planning Democracy, 2012. Re-valuing public participation in Scotland's planning system: A planning democracy advocacy paper – Discussion draft – April 2012 [online] Available from http://www.planningdemocracy.org.uk/resources/PAP_discuss_draft_web_April12.pdf

Renewable Energy Association [REA], 2012. Publications [online] Available from http://www.ref.org.uk/publications

Renewable UK, 2013. UK Wind Energy Database (UKWED) [online] Available from http://www.renewableuk.com/en/renewable-energy/wind-energy/uk-wind-energy-database/index.cfm/page/3/status/Consented/project_type/onshore

ResPublica, 2013. The Community Renewables Economy: Starting up, scaling up and spinning out – September 2013 [online] Available from http://www.respublica.org.uk/documents/yqq_Community%20Renewables%20Economy.pdf

RWE npower, 2012. Onshore-Sites in great Britain [online] Available from http://www.rwe.com/web/cms/en/1114282/rwe-innogy/sites/wind-onshore/united-kingdom/in-operation/

Scottish and Southern energy [SSE], 2012. Wind [online] Available from http://www.sse.com/WhatWeDo/Renewables/Wind/

Scottish Government, 2006. Planning etc. (Scotland) Act 2006 [online] Available from http://www.legislation.gov.uk/asp/2006/17/pdfs/asp_20060017_en.pdf

Scottish Government, 2007a. Planning – Community Engagement: Planning With People - PAN 81 [online] Available from http://www.scotland.gov.uk/Resource/Doc/169453/0047204.pdf

Scottish Government, 2007b. The Blacklaw renewable Energy Fund [online] Available from http://www.scotland.gov.uk/Publications/2007/10/09113958/32

Scottish Government, 2010a. Scottish Planning Policy – February 2010 [online] Available from http://www.scotland.gov.uk/Resource/Doc/300760/0093908.pdf

Scottish Government, 2010b. PAN 3/2010: Community Engagement – 30 August 2010 [online] Available from http://www.scotland.gov.uk/Publications/2010/08/30094454/12

Scottish Government, 2011. 2020 Routemap for renewable Energy in Scotland [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0120033.pdf

Scottish Power, 2012. Annual report 2011 [online] Available from http://www.iberdrolainforme2011.com/file/pdf/inf_0annualreport.pdf

Simpson, A. and Read, G. 2011. Written evidence submitted by Alan Simpson and Gerard Read – Submission to the House of Commons Energy and Climate Change and Environmental Audit Committee Inquiry into Solar Power Feed-in Tariffs: Vol II – 22 December 2011 [online] Available from http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/1605/1605vw.pdf

Slater, A.M. 2010. Law Essentials: Planning Law. Dundee University Press: Dundee

Strachan, P. 2012. Submission from Professor Peter A. Strachan - Evidence to the Economy Energy and Tourism Committee Inquiry into Renewable Energy (Targets) [online] Available from http://www.nuclearconsult.com/docs/consultation/ScottishGovernmentSubmission_ProfStrachan.pdf

Strachan, P. and Jones, D. 2012. Navigating a minefield? Wind power and local community benefit funds, in: Szarka, J., Cowell, R., Ellis, G., Strachan, P. and Warren, C. (eds) Wind Power Society and Governance: Lessons for Future Sustainable Energy. Palgrave.

UK Government, 2008. Planning Act 2008 [online] Available from http://www.legislation.gov.uk/ukpga/2008/29/pdfs/ukpga_20080029_en.pdf

Walker, G. and Cass, N. 2011. Public roles and socio-technical configurations: Diversity in renewable energy deployment in the UK and its implications, in: Devine-Wright, P (Ed), Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

Walker and Devine-Wright, 2008. Community renewable energy: what should it mean? Energy Policy 36(2): 497-500.

Walker, G., Devine-Wright, P. and Evans, B. 2005. UK Community Energies: Database. Community Energy Initiatives [online] Available from http://www.geography.lancs.ac.uk/cei/Community EnergyUKProjects.htm

Walker, G., Devine-Wright, P., Barnett, J., Burningham, K., Cass, N., Barton, J., Evans, B., Heath, Y., Infield, D., Parks, J. and Theobald, K. 2011. Symmetries, Expectations, Dynamics and Contexts: A framework for Understanding Public Engagement with Renewable Energy Projects, in: Devine-Wright, P (Ed), Renewable Energy and the Public: From NIMBY to Participation. Earthscan.

Warren, C. and McFadyen, M. 2008. Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland – ESRC/ISW Seminar: 4th November 2008 Queen's University, Belfast [online] Available from http://iws.rgu.ac.uk/abs/research/page.cfm?pge=75708

Warren, C. and McFadyen, M. 2010. Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland. Land Use Policy 27(2010): 204-213.

Wright, F. 2011. Evidence to the Economy Energy and Tourism Committee Inquiry into Renewable Energy (Targets): 15th Meeting 2011 Session 4 – Wednesday 7 December 2011 [online] Available from http://www.scottish.parliament.uk/parliamentarybusiness/28862.aspx?r=6829&mode=pdf

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee.

Wood, G. and Taylor, A. 2012. Offshore Wind - A Position paper: A Report for the Offshore Renewables Institute – December 2012.

8.4 The UK Electricity Network

The UK electricity network will need to undergo significant changes from now until 2020 and beyond in order to facilitate the Government's renewable energy and climate change targets.[282] In the report '*The Future of Britain's Electricity Networks*' the Energy and Climate Change Committee [ECCC], 2010: 11) points out that

> "*The transition to a low-carbon economy will require a fundamental change in the philosophy of power generation and supply, and the development and operation of a new, much larger and significantly more complex electrical energy system…* [It] *will transform the role of our electricity networks over the next 40 years. Whereas today the networks are seen as a means to an end in the transportation of electricity from generators to consumers, in the future they will play an integral and active role, enabling supply and demand to be managed in a much more complex and decentralised energy system. The market alone will not be able to deliver these changes—it requires strategic leadership from Government delivering a vision for the future that engages actively both consumers and the energy sector.*"

Meeting the 2020 RES-E sectoral target requires considerable growth in renewable electricity infrastructure deployment.[283] Not all of the anticipated infrastructure will be generating assets.[284] Growth in renewables requires connection to the electricity network. Of the estimated £110 billion in investment required, analysis carried out by DECC (2011a) and OFGEM (2010a) shows that around £35 billion will be required for the overall electricity transmission and distribution networks, both onshore (around £20 billion) and offshore (around £15 billion) (ECCC, 2010; OFGEM, 2012a).[285] As with

---

[282] The majority of the recent reforms to the UK electricity network (both transmission and distribution) were initially set out in the 2006 Department of Trade and Industry [DTI] report '*The Energy Challenge: Energy Review*' (DTI, 2006).

[283] Non-renewable generating infrastructure deployment is also required. DECC has also stated that up to 59 GW of new electricity generating capacity is urgently needed by 2025 (DECC, 2011b).

[284] Electricity network infrastructure can be divided into two main categories: transmission and distribution lines which can be carried on overhead pylons/towers, poles or alternatively underground or sub-sea cables and associated infrastructure (substations and converter stations) (DECC, 2011c). There will also be inter-array cables connecting the multiple arrays in a wind, wave or tidal stream development.

[285] There are uncertainties over the cost depending on whether or not particular reinforcements/upgrades or extensions will actually be required or developed. Such uncertainties are especially reflected in the case with the offshore transmission network that is still under development. Although a number of Crown Estate round 1 and 2 offshore wind projects have already connected, these

the generation supply side (see Chapter Six, page 191), it is clear that there is a need for unprecedented levels of investment to be sustained over a number of years against both a background of increased risk and uncertainty and the 2020 target deadline. This level of change requires new legal, technical, commercial and regulatory challenges to be overcome, particularly for the development of an offshore transmission network.

As with the planning system, the UK electricity network has also been viewed as a barrier to renewable deployment for a number of years (Wood and Dow, 2011). But what are the reasons for the electricity network acting as a barrier to deployment? Currently the electricity network in the UK and most industrialised nations generate the majority of their electricity in centralised power stations. Such generating plant is typically characterised by a relatively small number of large-scale fossil fuel (predominantly coal and gas) and nuclear power stations connected to a high-voltage national transmission network built up over the last seventy years to accommodate these conventional power stations (Boyle, 2004). The siting of conventional and nuclear generating plant was dictated primarily by access to fuel resources (coal), water resources (coal, CCGT gas and nuclear power) and access to the electricity and/or gas grids. Electricity is transported to areas of demand from where it is delivered to consumers via low-voltage regional distribution networks.

Renewable electricity technologies alter the *status quo* in a number of ways for both the transmission and distribution networks: as discussed in chapter four (section 4.4), RETs exhibit significantly different attributes in comparison to conventional and nuclear power stations. Although there are exceptions to this general rule, renewable electricity technologies exhibit high levels of geographic dispersal and are relatively small-scale in terms of generation output. One significant result of these attributes is that a large number of generating stations is required in contrast to conventional and nuclear generating technologies. The technology where this is most applicable is wind power, particularly onshore wind which can be connected to both the transmission and

---

developments are close to shore and projects coming forward will incur significantly higher costs as they are located farther from shore.

distribution networks. The problem for the former is that the decentralised attribute of onshore wind results in large numbers of wind farms widely dispersed throughout the UK requiring connection. As of November 2012, there were 330 operational wind farms in the UK with a further 81 under construction and 333 awaiting construction and a further 649 awaiting a planning decision (see Table 8.3). These numbers will rise substantially with onshore wind alone anticipated to increase from 4.6 GW in 2011 to 8-13 GW by 2020 according to UK Government analysis (DECC, 2011d).

In addition, the decreasing trend in the average size of onshore wind farms indicates that if this trend continues more developments will be required in the future as average projects become smaller in terms of installed capacity (see Figure 8.2). Currently, the transmission network is not designed for this format of multiple small-scale (in comparison to conventional and nuclear generation) connections with the result that there is currently not enough capacity and/or transmission infrastructure is absent in the locations where it is now or could be required. Although offshore wind and marine renewables exhibit similar characteristics there are two notable differences: these RETs could deploy individual generating plant at significantly larger scales in terms of generating output, thus reducing the overall number of developments in comparison to onshore wind (particularly offshore wind)[286]; and the geographic dispersal of these technologies in terms of deployment, is more constrained than onshore wind due to the centralisation of ownership primarily by the Crown Estate (Wood and Taylor, 2012).[287] Critically, there is no transmission network *per se* for offshore renewables and as deployment of both generating and transmission infrastructure progresses, onshore network development will be crucial (see below).[288]

---

[286] As of November 2012 there were 20 operational offshore wind farms with 4 under construction, 7 awaiting construction and 12 awaiting planning determination (see Table 7.3, page 268).

[287] As of June 2012, there were 15 offshore wind farms outside the Crown Estate licensing schemes accounting for approximately 330 MW installed capacity if all projects are commissioned (Crown Estate, 2012; National Audit Office [NAO], 2012).

[288] Currently existing offshore wind farms are being connected separately via point-to-point transmission lines; in the near future a more connected or 'holistic' offshore transmission system is envisaged although there are problems with this proposed approach (NAO, 2012).

The distribution network is also not adapted to connecting large numbers of what is termed embedded or distributed generating plant. These are typically generating plant that are either too far away or are too small to be connected directly to the transmission network and include small-scale biomass including anaerobic digestion, hydro power, solar PV arrays (particularly if the latter start to deploy above the 5MW scale) and onshore wind. Despite the associated benefits of such '*embedded generation*', including reducing the need to upgrade or reinforce the transmission network and a reduction in transmission (electricity) losses due to the physical connections being closer to demand sources, a major issue is that the distribution network is passive (Greenpeace, 2005). This means that at the moment there is very little generating plant connected to the low-voltage network.[289] However, this is highly likely to change: since 2002 there has been a steady increase in the number of renewable deployments, mainly solar PV and to a lesser extent onshore wind, connecting to the distribution network. The RES-E target may drive further increases at this level. Although generation under the current FIT mechanism, and to a lesser extent microgeneration technologies, will account for a significant proportion of generating plant linked to the distribution network, there will also be a significant contribution from >5 MW meso-scale deployment: as of the end of 2011, 25 per cent (1,036MW) of total UK operational onshore wind capacity was less than 25 MW installed capacity (DECC, 2012a).[290] This will be compounded by the trend in the average size of onshore wind farms decreasing due to the utilisation of large-scale sites and other barriers (including planning). Incorporating increased levels of generating plant of different sizes and types at different locations will require new control systems and the integration of demand management (Watson, 2010). Increased renewable deployment at this scale will also require upgrade and possible extension of the distribution network.

---

[289] In addition, power flows in one direction and is fairly predictable in terms of daily and seasonal demand fluctuations. The distribution network has largely been passive since the mid-1940's onwards.

[290] This increases to 50% for 25-50MW onshore wind deployments. Looking at hydro power, 34% of total operational UK capacity is <25MW and 28% is 25-50MW. In contrast, only 2.5% of offshore wind farms are <25MW and 25% 25-50MW (DECC, 2012a). However, it should be pointed out that these statistics taken from DECC's '*Digest of UK Energy Statistics*' (DUKES) documents do not cover all such RET deployment: onshore wind (1,278 MW); hydro (232 MW). However, the reason for this is not made clear.

Another key characteristic of the UK electricity transmission system is, in broad terms, the transfer of power from the north (Scotland) to the south (England and Wales). This power flow from north to south also means from northern to central Scotland, from the central belt to southern Scotland and from the south to England and Wales, encompassing the Scottish Hydro Electric Transmission Limited (SHETL), Scottish Power Transmission (SPT) and National Grid Electricity Transmission (NGET) networks via the Scotland-England interconnector.[291] In general terms, the disposition of demand and generation matches this, and the trend is highly likely to increase up to 2020 and beyond as the result of increased power export through Scotland and into England, due primarily to the anticipated contracted renewable energy deployment throughout Scotland (National Grid, 2009).

As stated in chapter eight (see Section 8.2), Scotland currently accounts for 63 per cent of total UK operational onshore wind capacity, with over two-thirds of capacity under construction, 56 per cent of capacity awaiting construction and 61 per cent of capacity awaiting a planning decision. In contrast, England accounts for the overwhelming majority of offshore wind development in the post-consent planning regime: 90 per cent of operational capacity, 100 per cent of capacity under construction and over 99 per cent of capacity awaiting construction. When the '*application submitted*' category is examined, however, Scotland accounts for a greater proportion of potential capacity coming through the planning pipeline: 66 per cent in comparison to 34 per cent in England although this will change if and when the substantially larger Crown Estate Round 3 projects come forward. The trend for key biomass electricity technologies is similar, with England dominating current and anticipated deployment. These statistics

[291] The transmission network in England and Wales is owned and operated by National Grid Electricity Transmission (NGET). Subsidiaries of Scottish Power (Scottish Power Transmission, SPT) and Scottish and Southern Energy (Scottish Hydro Electric Transmission Limited, SHETL) each own and maintain the southern and northern parts of the transmission system in Scotland, respectively. Both Scottish transmission and distribution companies also own generating assets and supply companies: this is called 'vertical integration' and is absent in England and Wales. National Grid, as the transmission system operator, has responsibility for overseeing and managing the flow of electricity across the whole British network. The 14 distribution networks across England, Scotland and Wales are owned and operated by 7 distribution network operators (DNOs). Within Scotland, Scottish Power and Scottish and Southern Energy own the distribution (as well as the transmission networks) in their respective regions (ECCC, 2010).

are not definite: there will be those projects that do not reach the operational stage for various reasons (including grid issues); additionally, new projects (including previously withdrawn/refused developments) will come forward. Offshore wind is a prime example: overall, there is around 46 GW of offshore wind projects and 1.6 GW of wave and tidal stream at all stages of the development pipeline, of which 11 GW of offshore and virtually all marine deployment are located in Scotland (Crown Estate, 2012a; Wood, 2010; Wood and Taylor, 2012).

However, there are already constraints on the network in terms of capacity available now and into the future for new connections. The Electricity Network Strategy Group [ENSG] updated report '*Our Electricity Transmission Network: A Vision For 2020*' (ENSG, 2012)[292] shows that although network constraints exist at various locations across the UK (North Wales-Mid-Wales, South West, East Coast and Anglia and London), such constraints are particularly acute both within Scotland (between the northern zone (SHETL) and the southern zone (SPT) and between Scotland and England (SPT/NGET interface). In addition, the Scottish Islands with particular reference to Shetland, Orkney and the Western Isles have excellent wind and marine resources. This is important for a number of reasons: Scotland has exceptionally high quality renewable resource levels for onshore wind, offshore wind and marine renewables; the bulk of onshore deployment is anticipated to come from Scotland, along with a significant proportion of offshore wind (around a third) and virtually all marine RET deployment currently; an estimated 65 per cent of the total spend required on the UK transmission network to accommodate the anticipated renewable and non-renewable generation plant will be in Scotland.[293] This highlights the importance of Scotland towards meeting the 2020 RES-E sectoral target. In addition, the Scottish Government has set a demanding target of 16-

---

[292] ENSG is a high level forum bringing together key stakeholders (including network companies, generators, trade associations and devolved administrations) in electricity networks and is jointly chaired by both DECC and OFGEM. The broad aim is "*… to identify, and co-ordinate work to help address key strategic issues that affect the electricity networks in the transition to a low-carbon future.*" (DECC, 2012a: 1).

[293] According to the latest ENSG report (2012), major work on the network required to accommodate the necessary generation deployment is expected to total £8,820 million: Scotland (5,740 million), Wales (1,260 million, 12%) and England (1,370 million, 21%) (ENSG, 2012). In the previous ENSG 2009 report, Scotland was estimated to account for 57% of the total UK spend (ENSG, 2009a).

17 GW of renewable electricity technology deployment by 2020. Onshore wind, and increasingly offshore wind, will account for the majority of Scottish deployment.

Out of the UK total of 78 GW of prospective new projects (all generating types) awaiting connection to the onshore grid, 19 GW are renewable projects of which over 12 GW are located in Scotland (DECC, 2010). Around 17 GW of Round 3 offshore wind capacity at the UK level has also entered into connection agreements with National Grid (National Grid and the Crown Estate, 2011). Currently demand for network capacity exceeds supply. This can be seen by the fact that a number of renewable generating projects have been offered connection dates ten years or more into the future (House of Lord's Select Committee on Economic Affairs, 2008). In addition, as of November 2012, there was almost 1,000 MW of onshore wind in Scotland applying for connection dates prior to submitting the relevant planning application (see Table 8.2).

What does this mean for the electricity network? OFGEM (2008a: 1) states the issues clearly:

> "*Enabling renewable and other low carbon generators to secure timely access to the electricity transmission network (the "grid") is critical if we are to meet our climate change and renewable energy targets. To achieve this, we need access rules and commercial incentives on the Grid companies to make the best use of the existing transmission capacity and to invest as quickly as possible to deliver more capacity when it is required… This sets an unprecedented challenge for our electricity networks, creating an urgent need to have in place grid access arrangements that allow large volumes of new renewable and other essential low carbon and conventional generation to connect quickly. It requires generators to be offered connection dates, which are reasonably consistent with their project development timetables and for early steps to be taken to deliver essential investment in the grid.*"

The critical point here is that transmission and distribution infrastructure upgrade/reinforcement and extension needs to be consistent with generating asset deployment. It is not enough to simply upgrade/reinforce existing or construct new grid infrastructure for two main reasons: building sufficient grid capacity to meet all anticipated generation demand would be expensive, with the resultant impact on consumer costs; and the need to avoid developers delaying or deciding against constructing renewable plant or the duplication of infrastructure and/or stranded assets.[294] These issues are compounded by the fact that whilst it is recognised that a significant volume of primarily wind power will be required to connect to the electricity network over the coming years, the exact volume, timing and location are largely uncertain. As a result, connection of these generating assets presents a particular difficulty. In other words, to meet the RES-E sectoral target by 2020 there is a need to connect large volumes of renewable generation to the electricity network quickly (due to the demanding timetable) and in a timely fashion in order to match generation assets to grid infrastructure assets.[295]

Transmission and distribution infrastructure also requires planning consent, although it should be noted that a developer can apply for connection prior to obtaining planning consent. As with renewable infrastructure, there are planning concerns: such infrastructure can in effect '*industrialise*' the landscape with impacts on the landscape and visual amenity, biodiversity and public health (noise and electric and magnetic fields) (DECC, 2011c). The planning system, therefore, is another issue that could increase the difficulty in attempting to synchronise network and generating asset deployment (see below).

Another major issue concerns the access and allocation of electricity network capacity. There are a number of ways in which this can be addressed (in addition to identifying likely transmission/generation scenarios and the associated investment costs): by bringing forward connection dates; introducing incentives to invest in capacity by network companies; and looking at alternatives to charging (locational and use of system costs) (Wood, 2010). As with increasing physical capacity infrastructure, such

---

[294] This is where a particular infrastructure is constructed but has either no way to connect to the grid and thus generate renewable electricity or vice versa (operational grid with no power plants to connect). Again, this would have costs largely unacceptable to consumers and government.

[295] Of course other non-renewable generation assets will require connection to the electricity network. However, due to the different attributes of conventional and nuclear generation to renewable technologies, such plant is most likely to be sited where there is already existing grid infrastructure and it is anticipated that a large proportion will either replace existing assets (coal to biomass or gas, replacement nuclear plants in the same location as aging nuclear stations) or existing assets will have their lifespan extended (nuclear).

solutions also have its own challenges and problems: a regime for transmission access should ensure speed (quick connection), certainty (in terms of what the charges are going to be) and a low total cost. Such requirements will involve trade-offs, resulting in difficulty to deliver all three objectives (Lawton, 2009). Because of the lengthy delays in connecting to the transmission network, with some developments having to wait until after 2020 for connection and the resultant issues regarding the 2020 target, OFGEM and the UK Government have proposed and/or introduced a number of substantial and wide-ranging reforms.

A number of the issues discussed above serve to highlight the fundamental tensions regarding the UK electricity network and ultimately, what vision exists for the future low-carbon network: should the UK keep a large-scale network or move towards a decentralised system? Maintaining the focus on a centralised network and by default large-scale generation runs the risk of emphasising this scale at the expense of smaller-scale energy developments. Given the trends in current and anticipated renewable deployment towards meso-scale deployment, for onshore renewables and onshore wind in particular, this has implications for meso-scale deployment with an emphasis on community and locally-owned renewable deployment and increasing public participation and engagement on issues of energy and climate change. As such, the increasing adoption of a decentralised approach could alleviate or remove a number of the barriers that currently constrain renewable technology deployment.[296] In addition,

[296] Dr Pollitt makes the point succinctly: "*I think this is potentially very important and very exciting. It plays to actually engaging with the public on issues of climate change and getting public acceptability for adjusting our energy, and I think it is an under-exploited opportunity at the moment to move more into local energy service company provision and to engage people with smaller companies and smaller investments, and to look to exploit local energy resources. Longer term, these are the sorts of experiments that we should be doing now because they may pay off very, very substantially later on. They are difficult—no one pretends it is easy—and if you talk to any of the incumbents they will probably tell you that this is all terribly difficult, and any interactions that we have had with small energy service companies raise questions about their competence and: "We think we can do it better". But I think this is an area where we do need much more experimentation and where we have got the chance to actually get public support for doing something about climate change, because people can see and be engaged with it locally and engage with changing their behaviour because they are engaging with a local company. If it is a big national company telling you what to do you are very unlikely to do it. Also, I think, it offers the prospect of lots of innovation because different things will happen in different places; different technologies will be trialled, supply and demand will be traded off much more effectively; new ownership forms may come forward, so we may see customer-owned assets or public/private partnerships, which may all be necessary to achieve these very ambitious targets.*" (Pollitt, 2010: 17-18).

what role is there for anticipation in the system? Although there are valid concerns regarding the matching of network and generation assets, this issue points to the need for a focus on the identification of strategic infrastructure investment planning (Watson *et al*., 2010). This has particular implications for the offshore networks required to connect both offshore wind and marine technologies and the critical reliance on the onshore system. What is clear is that a strategic '*vision*' will be required at least in terms of delivering the required infrastructure in a quick and timely fashion.

8.4.1 Upgrading the Electricity Transmission Network

The information used here for the onshore transmission network is based primarily on the outputs from the various ENSG reports (ENSG 2009a; ENSG 2009b; and ENSG, 2012).[297] The aim of the ENSG reports is to identify and evaluate a range of potential electricity transmission network solutions that would be required to accommodate the level of RES-E generation sufficient to meet the 2020 sectoral target (ENSG, 2009). This is based on National Grid's '*Gone Green 2011*' scenario which envisages the generation mix installed capacity for 2020: 16.5 GW (17 per cent) offshore wind, 11.2 GW (10 per cent) onshore wind and 3.1 GW (3 per cent) other renewables.[298] This level of deployment is expected to result in around 31 per cent of total electricity generation from renewable sources. It is interesting to note the difference between deployment estimates used by DECC and National Grid. This highlights the inherent uncertainty:

> "*The potential reinforcements are phased to be delivered in line with the prospective growth of renewable generation in each region. It is recognised that there will continue to be a degree of uncertainty about the volume and timing of generation growth in any given area.*" (ENSG, 2012: 7).

[297] ENSG 2009 was the first report. ENSG provided an addendum report containing further analysis looking out to 2030. ENSG 2012 is an update of the previous reports. It is also worth noting the importance of the ENSG reports: "*The Government believes that the ENSG work represents the best available overview of where the electricity networks will need to be reinforced and augmented in order to achieve the UK's renewable energy and security of supply targets.*" (DECC, 2011e).

[298] Gas would account for the largest contribution (35.5 GW, 36%), followed by coal (14.5 GW, 14%) and nuclear (12.3 GW, 12%) with other sources (9.3 GW, 9%) (National Grid, 2012).

In addition, there is uncertainty regarding which technologies will deploy, although wind power is anticipated to contribute the bulk of RES-E deployment. This uncertainty also applies for the developing offshore transmission network.

8.4.1.1 The transmission network options

Table 8.8 (see pages 380-381) shows the key electricity transmission network options for Scotland and the Scotland-England interface in addition to currently authorised transmission work already in progress and/or under construction which includes the Beauly-Denny rebuild, Beauly-Dounreay upgrade, Beauly-Kintore re-conductoring and up-rating the interconnector between Scotland and England (from 2.2 GW to 3.3 GW) (Scottish and Southern Energy, 2012a, b; Wood, 2010). This work is termed the first SHETL phase of upgrades. Although these reinforcements are critical steps in developing sufficient capacity to accommodate renewable projects, they are just one step in the process. Further improvements to the mainland system are required to maximise the use of existing infrastructure and overhead line routes to connect the Scottish mainland to the islands (primarily the Western Isles, Orkney and Shetland) and provide the capacity required to bring the offshore generation onshore. The second SHETL phase includes the reinforcement of the Caithness to Moray line (from Spittal to Blackhillock) with an offshore 1200 MW HVDC hub in the Moray Firth which would link directly to a 600MW HVDC link to Shetland (at Kergord).

There are three main elements to upgrading the system with regard to the linkage between the SHETL to SPT areas, and on to the north of England. These include: the 'Incremental' upgrade involving reconductoring and reinsulation work on existing tower routes, and developing new and existing substations and the installation of series compensation). This would include the SHETL East Coast upgrade from 275 to 400kV (from Blackhillock to Kincardine with an extension from Blackhillock to Peterhead), the SPT East Coast upgrade (requiring three new 400kV substations at Kincardine, Grangemouth and Harbum and the up-rating of 40km of overhead line to 400kV

Table 8.8 Key electricity transmission network options for Scotland

Status	Name	Details	Earliest date of completion
ongoing	Beauly-Denny	Install a 137-mile 400kV overhead electricity transmission line (to replace an existing 132kV overhead transmission line)	2014
ongoing	Beauly-Dounreay	Reinforcement of the existing 153km 275kV overhead transmission line; upgrading the existing Dounreay substation and constructing 2 new substations at Fyrish and Loch Buidhe (both 275kV/132kV)	2014
ongoing	Beauly-Kintore	Refurbishment works to the existing transmission line including the replacement of existing conductors (wires) with modern conductors	2014-15
proposed	Caithness-Moray	Reinforcement of the Caithness-Moray line (from Spittal to Blackhillock) with a new 1200MW HVDC hub in the Moray Firth which would link directly to a 600MW HVDC link to Shetland (at Kergord)	2016
proposed	SHETL East Coast Upgrade	Upgrading existing transmission line from Blackhillock to Kincardine in the central belt via Aberdeen, Dundee and Alyth; line extension from Blackhillock to Peterhead	2016
proposed	SPT East Coast Upgrade	Up-rating 40km of overhead transmission line to 400kV; construction of three new substations at Kincardine, Grangemouth and Harbum	2017
proposed	SPT East-West Upgrades	Install 2 new bays at Denny 400kV and Wishaw 400kV; establish 17km of 400kV overhead line; up rate Bonnybridge substation to 400kV/132kV and modify associated connections	2017
proposed	Harker-Quernore	Reconductoring existing double circuit overhead transmission line	2014

Table 8.8 (Continued)

Status	Name	Details	Earliest date of completion
proposed	SPT/NGET Series Compensation	Compensation of Harker-Hutton route, Eccles-Stella West route and Strathaven-Harker route; Shunt compensation at Harker, Hutton, Stella West and Cockenzie; East-West 400kV upgrade of overhead transmission line; Up rate Strathaven-Smeaton to 400kV double circuit operation and up rate 400kV cables at Torness	2015
proposed	Western Subsea HVDC Link	New 400kV GIS at Deeside; 400km 1.8-2.1GW HVDC cable connection from Deeside (England) to Hunterston (Scotland) with submarine and land sections; 2 DC converter installation at Deeside and Hunterston	2015
proposed	NGET-SHETL East Coast HVDC Link 1	~2GW HVDC cable connection from Peterhead (Scotland) to Hawthorn Pit (England); Associated AC network reinforcement works on the Peterhead network; Converter installation at Peterhead; Re-insulating existing 275kV Peterhead-Rothienorman overhead transmission line to 400kV	2018
proposed	Western Isles HVDC Link	450MW HVDC link between Gabhair (Lewis) and Beauly (on the mainland)	2015
proposed	Orkney Islands AC Link	1 * 180MVA 132kV AC link between Dounreay (on the mainland) and West of Orkney (Orkney)	2015
proposed	Orkney Islands HVDC Link	600MW HVDC link between West of Orkney and Sinclairs Bay HVDC hub (Orkney); 1200MW link between Sinclairs Bay HVDC hub and Peterhead (on the mainland)	2020+
proposed	Shetland Islands HVDC Link	600MW HVDC link between Kergord (Shetland) and the Moray Firth Offshore hub	2017

SOURCE: ENSG (2009a; 2009b; 2012)

capacity)[299], the SPT East-West upgrades, SPT/NGET series compensation and NGET reconductoring at Harker-Quernmore. Together with the first proposed phase (SHETL area), this would provide a transmission system in the SHETL area capable of accommodating 5.5 GW of renewables (Stage 1 ENSG). The second element involves a Western Subsea HVDC 1.8-2.1 GW link between Hunterston and Deeside to provide additional capacity across the interconnector circuits and additional capacity across the upper north of England area. The third element involves a parallel Eastern Subsea HVDC ~2.1 GW between Peterhead (SHETL, Scotland) and Hawthorn Pit (England, NGET) in order to provide additional capacity primarily across the Central Scotland/North of England key transmission boundary, particularly for the proposed offshore wind developments. The Eastern Subsea link, in combination with the two proposed phases within the SHETL area would be required to accommodate 6.9 GW of renewables (Stage 2 ENSG).

In summary, all three reinforcements (SHETL first proposed phase and the 'Incremental' reinforcements, SHETL second phase and the Eastern Subsea HVDC link and the Western Subsea Link) are required by 2020 in order for connecting 11.4 GW of renewable projects in Scotland and any two reinforcements for 8 GW. According to the ENSG 2009 report, any single reinforcement project would have been sufficient to meet the Scottish Executive's previous RES-E target of 50 per cent.[300] However, the target has been increased to approximately 16-17 GW of renewable capacity by 2020. If achieved, this would require a substantially increased amount of transmission capacity.[301] As such, there are also a number of additional transmission network upgrades proposed in

---

[299] The ENSG 2012 report put forward an alternative to the East Coast upgrade: a possible second 2 GW NGET-SHETL East Coast HVDC Link (Link 2). This would require associated AC network reinforcement (at Peterhead) but could also provide possible offshore HVDC integration in the Firth of Forth area (for Round 3 and STW offshore wind farm developments).

[300] However this seems a very low amount to achieve the 50 per cent RES-E target: it is likely that over 8 GW of installed capacity will be required to meet the 2020 RES-E target of 50 per cent. Therefore, in contrast to the ENSG 2009 report, it is possible that two major reinforcements would have been required if the target remained set at the same level (Wood, 2010).

[301] There is also concern that Scotland will have to make up for any deployment (and thus generation) shortfall from England and/or Wales (ENSG, 2009).

Scotland. In particular, these include links to three major Scottish Island groups: the Western Isles (450MW HVDC link between Gabhair on Lewis and Beauly near Inverness); the Orkney Islands (a 132kV AC link between Dounreay and West of Orkney, a 600MW HVDC link between West of Orkney and Sinclairs Bay HVDC hub and a 1200MW link between Sinclairs Bay HVDC hub and Peterhead); the Shetland Islands (a 600MW HVDC link between Kergord and the Moray Firth Offshore hub).[302]

It is clear from Table 8.8 that the completion dates for a significant number of key transmission projects deemed necessary are now projected to be delayed. This includes the critical Beauly-Denny rebuild and upgrade with construction estimated to take an extra year. Such delays would affect 17 transmission reinforcements over 2-4 years and affect 21 potential contracted developers accounting for around 2.4 GW: 1 GW onshore wind (of which 640MW have planning consent); 1.1GW offshore wind (none consented) and 300MW of wave and tidal power (none consented) (ENSG, 2013). However, there are valid concerns that delays on generation due to the new delivery dates could affect more than 2.4GW of renewable deployment due to the impact of delays on the first deployment phases potentially impacting subsequent phases. As Round 3 and Scottish Territorial Waters (STW) offshore wind developments come forward this could significantly increase the amount of deployment delayed (see below).[303] An important conclusion is that the key transmission works entail a sequence of key stages that consist of a number of individual works and that the connection of generation infrastructure is dependent on at least a number of such works being completed. This is particularly relevant for offshore renewables.

---

302 The transmission network projects discussed in text (actual and proposed) do not represent an exhaustive list of such proposals (e.g. the Kintyre-Hunterston AC Subsea link); however, these are the main works required in order to connect anticipated generation demand at least to 2020 and beyond (ENSG, 2009b, 2012).

303 As of November 2012, there is 4,755MW of STW projects (5 sites: Argyll Array (1.8GW); Beatrice (1GW); Inch Cape (905MW); Islay 690MW; Neart na Gaoithe (450MW) and up to 5,000MW of Round 3 projects (Moray Firth (1.3-1.5GW); Firth of Forth (3.5GW) located in Scotland with Crown Estate exclusive licensing agreements (Wood and Taylor, 2012). Regarding marine renewables, there is 1,600MW (6 wave projects (600MW) and 5 tidal stream projects (1,000MW) (Crown Estates, 2012b).

An additional issue within Scotland is that of currently limited or no transmission capacity or where the capacity of proposed works is already contracted for. This is particularly the case for the peripheral (and island) areas of Scotland which have very limited or no capacity either with the mainland or within and between the various islands that comprise the major island groups: Shetland has no grid connection with the mainland with very limited capacity available for further generation; only 9 per cent of the proposed Western Isles HVDC link capacity will be available if the link is constructed and if all the generation assets already with connection agreements go ahead; Orkney is currently connected by a 33kV cable and existing generation capacity (66.7MW) is regularly curtailed due in part to grid capacity with the result that no generation (even microgeneration) can connect until proposed works are completed. The 600MW HVDC proposed link for Orkney is already potentially half-full (320MW have already submitted connection applications). Yet the Scottish islands have potentially around at least 3.5GW of installed capacity available (Redpoint and TNEI, 2013; Wood, 2010).[304] The delay in additional export capacity until 2018 at the earliest will essentially prevent the sale of electricity from the islands, with a particular impact on smaller-scale generation deployment such as marine renewables as they await a larger project (typically onshore or offshore wind) to provide the need justification for future transmission capabilities. Importantly, these links are also dependent on the mainland transmission works listed in Table 8.8 being completed (for example, the East Coast upgrade).

The impact of the delays in key transmission work will impact both onshore and offshore renewables:

> "*The delivery of offshore* [renewable] *generation projects is closely linked to the completion of the onshore transmission works outlined by ENSG (I.e. the onshore transmission works can be considered as an enabler for the offshore projects.*" (Pöyry, 2009: 75).

[304] Another example would include the Hunterston-Kintyre link to provide transmission capacity for Argyll and the Kintyre peninsula.

The same issues exist for the potential 11GW of offshore renewable projects. These include: offshore wind (Round 3 and Scottish Territoriality Waters) and wave and tidal stream power (Pentland Firth and Orkney Waters developments). As of November 2012, there are 3,997MW of offshore wind and 300MW of tidal stream power awaiting planning determination in Scotland (Crown Estates, 2012b; Wood and Taylor, 2012). This means that there is still another 6GW of marine renewables anticipated to come forward in the near future, with roughly similar development timeframes for all three technologies (Wood, 2010). In particular, the location of the marine renewable projects already with Crown Estate licensing agreements means that these will be heavily dependent on the Orkney and Shetland connections in addition to being further dependent on the various stages or sequences of onshore transmission network being completed.

However, Table 8.9 (page 386) reveals that the impact from the potential capacity anticipated from offshore wind might not be as significant as assumed. An analysis of the data for Round 1 and 2 of the Crown Estate's UK-wide offshore wind leasing programme shows that the volume and timing of deployment is staggered. On the basis of whether or not a project is operational or not, only 12 per cent of all Round 1 and 2 proposed projects were operational in 2010. Although almost all Round 1 projects announced in 2000 are operational (95 per cent over the last ten years, of which 1,122MW are operational), Round 2 projects announced in 2003 have not been as successful: only one project with an installed capacity of 64 MW was operational representing just 0.9 per cent total installed capacity after seven years. By 2013, almost half (43 per cent) of all projects were operational.[305] If the projects in the category '*in construction*' are added to those operational, this would include 60 per cent of all licensed capacity. Of interest, 84 per cent of all projects have planning consent (although this figure does not take into account those projects withdrawn or refused

[305] Although this appears to be highly unrealistic, it was originally intended that most Round 1 projects would begin generating in 2005, with Round 2 projects coming online from 2007 (Mitchell, 2010).

Table 8.9 The Crown Estates offshore wind leasing agreements - Rounds 1 and 2

	2010		2013	
Round 1 - announced 2000	**Capacity (MW)**	**Number of projects**	**Capacity (MW)**	**Number of projects**
Operational	1,112	12	1,112	12
In construction			62.1	1
Not constructed	62.1	1		
Total	**1,174**	**13**	**1,174**	**13**
Total installed capacity (as a %)	95%		95%	
Round 2 - announced 2003				
Operational	64	1	2,180	7
In construction	1,119	3	1,226	3
Not constructed with planning consent	3,038	6	1,839	5
Not constructed - in the planning process	3,080	6	1,200	1
Total	**7,301**	**16**	**6,445**	**16**
Total installed capacity (as a %)	1%		34%	
Round 1 and 2				
Total in operation	1,030	13	3,292	19
Total	8,475	16	7,619	10
Total round 1 and 2 installed capacity (as a %)	**12%**		**43%**	

SOURCE: Crown Estates, 2010, 2013; Wood, 2010.

Note: Total offshore wind capacity dropped between 2010 and 2013 due to developments withdrawn or refused planning consent

consent, see Table 8.3).[306] This would appear to reduce the short-term impact on the electricity transmission network, and importantly, the *need* for the key works listed in Table 8.8 to be deployed as quickly as possible. It is not unreasonable to suggest that this could also apply to the Crown Estate's wave and tidal stream programme. However, the sheer scale of the Round 3 offshore projects coming forward now and in the near future could negate this. In addition, this could result in less than predicted overall installed renewable capacity for the 2020 target.

Offshore renewable projects also require connection to the onshore network. Prior to the deployment of the first offshore wind farm in 2003, there was no need for an offshore transmission network. As of November 2012, there are 20 operational offshore wind farms, with a further 4 under construction and one awaiting construction with a combined installed capacity of over 6GW out of the total 8GW offered under the first two CE rounds. The UK offshore transmission regime is currently in the early stages of development and is being delivered in two parts: a transitional and an enduring regime. Under the transitional regime, which commenced in June 2009, the necessary transmission assets are constructed by the developer of the offshore generation infrastructure (NAO, 2012). Under the enduring regime (from 31 March 2012), offshore developers have the flexibility to choose whether to design, finance, construct, operate and maintain the transmission assets themselves ('*Generator build*') or to leave this to an offshore transmission operator ('*OFTO build*'). Regardless of the party constructing the offshore transmission assets, an OFTO will be ultimately responsible for the post-construction ownership and operation of the assets (OFGEM, 2012b).[307]

So far, there have been two transitional rounds with 6 offshore transmission networks fully operational, linking eight offshore wind farms to the onshore system. In addition, one other is partially complete with two more in progress with four more in the early

[306] In 2010, 58 per cent of all Round 2 projects have already received planning consent with 100 per cent for Round 1.

[307] An OFTO is appointed through a competitive tender process facilitated by OFGEM. In essence, qualifying companies bid to become the OFTO for a particular network (National Grid, 2011).

stages (under the second transitional round).[308] Designed and constructed by the offshore wind farm developer, and in conjunction with the small-scale, near shore characteristics of the early Round 1 and smaller Round2 developments, this has led to such infrastructure being connected separately via point-to-point transmission lines from an offshore substation to a suitable onshore substation utilising existing transmission technology (National Grid, 2011). The benefits of this approach include mitigating the economic and technological risk facing these early developments (see below) and helping to ensure that the generating assets are deployed on a similar timetable to the necessary transmission assets: this is critical for the wind farm to commence entering electricity into the grid and receive subsidy in addition to the sale of electricity. However, concerns with a 'point-to-point' dedicated wind farm approach are potential duplication of infrastructure (when wind farms are in close proximity) with a resultant increase in environmental and economic/social uses of an already congested '*marinescape*' (see Section 8.2.3.2).[309] In addition, this approach would limit the subsequent development of a more coordinated and integrated offshore transmission system.

It is the significantly larger-scale, farther from shore and thus increasingly complex Round 3 developments that have led lead to the questioning of the economic value and simplicity of the current connection approach. In particular, a number of the proposed Round 3 developments are clustered geographically (for example, the Dogger Bank, Hornsea and East Anglia wind farms with a combined capacity of 23GW in the East England and Anglia area alone, see below). In the joint OFGEM and DECC report '*Offshore Transmission Coordination Conclusions Report – 1 March 2012*', it is argued that a more coordinated approach would result in reduced overall capital and operating

---

308 Transitional Round 1: operational (Barrow (90MW), Robin Rigg East and West (180MW), Gunfleet Sands 1 & 2 (173MW), Ormonde (150MW) and Walney I (184MW) and II (184MW); partially complete (Thanet, 300MW); in progress (Sheringham Shoal (315MW) and Greater Gabbard (504MW). Transitional Round2 is split into 2 tranches: Transitional Round 2a: Lincs (270MW), London Array (630MW), Gwynt y Mor (576MW). Transitional Round 2b: West of Duddon Sands (389MW) (OFGEM, 2012c, d).

309 An increased number of offshore cables and associated infrastructure could compound the problems around potential overlap between existing and future offshore renewable generating and transmission infrastructure and marine protected areas (see Section 8.2.3.2).

expenditure and thus costs; reduce environmental impacts (through the need for less transmission cables and potentially other associated infrastructure); reduce the impact on the onshore transmission system; and limit the number of planning and consenting issues (OFGEM and DECC, 2012).[310] Additionally, a coordinated approach would both anticipate the connection needs of future offshore wind farms and potentially permit the early identification of supply chain requirements (such as HVDC cables) for the necessary transmission work. However, such an approach could result in stranded assets due to the number of different projects with different developers involved and not all the required technologies are either available or proven (such as 2GW HVDC cables and HVDC multi-terminal links).

An important question is: why are a significant number of key transmission works being delayed? There is an urgent need for correlating the development of renewable and transmission projects. However, there are a number of potential issues with the proposed changes to the electricity transmission network that make this difficult. The requirement to obtain planning consent is one such issue. Figure 8.4 shows the project development times for an onshore wind farm, overhead transmission line and substation. These development times represent average or typical durations. With regard to Part B, planning permission and consents is approximately three years but overall, this timeframe assumes moderate levels of public reaction to the proposal and no significant environmental or local impact issues arising that require major revision to the project design (ENSG, 2009). This applies equally to renewable energy projects, with onshore and offshore wind being of particular importance. The duration in gaining planning consent is also dependent on the particular projects characteristics.

However, two recent major extension/upgrades of the transmission network in both England and Scotland serve to highlight the difficulties involved: the 137 mile Beauly-Denny transmission line has taken 6 years from planning application submission to determination; consent for the North Yorkshire transmission line has taken 6.4 years.

[310] This report is based on two reports commissioned by OFGEM: See Redpoint (2011) and TNEI and PPA Energy (2011).

The planning application for Beauly-Denny was submitted on 28 September 2005 with a public hearing held from 6 February 2007 to 20 December 2007. Planning consent was awarded in January 2010 (Scottish Government, 2010). First conceived in 2001 and estimated to be completed in 2014, indicating an overall time of at least 9 years. The planning application for the North Yorkshire transmission line was submitted in December 1991. Two public inquiries were held (from May to December 1992 and March to April 1995) with planning consent determined in March 1998 (Communities and Local Government, Department for the Environment, Food and Rural Affairs, Department of Trade and Industry and the Department for Transport, 2007). Taking 4 years to construct, in total the project required over 10 years to reach operation (Select Committee on European Union, 2008; Wood, 2010). Both developments, although ultimately successful in terms of gaining planning consent, faced significant public opposition and environmental hurdles (ECCC, 2010).

As discussed before, the reform of the Scottish Planning system should make the process quicker: by allocating proposed nationally-significant transmission work to the current National Planning Framework (NPF 2), they should proceed more quickly through the planning system than before (See Section 8.2).[311] The NPF 2 includes the islands reinforcements (Orkney, Shetland and the Western Isles), the Dounreay-Beauly upgrade, Beauly-Keith reinforcement, East Coast upgrade and the Scotland-England interconnector upgrade, which should help avoid other 'Beauly-Denny' situations. In addition, any projects which are designated as a major development (within the '*hierarchy of developments*') can be subject to call-in by Scottish Ministers to speed up the process. However, there are two main issues of concern here: this could lead to a top-down imposition of projects with a resultant currently unquantifiable level of opposition and backlash, and not all the transmission projects proposed are within the current NPF - in particular the Eastern and Western Subsea HVDC links. Although they could be added to the next National Planning Framework (NPF 3) scheduled for 2014, this could lead to unforeseen problems and the 2020 targets will be less than six years

[311] Recent planning reforms in England (for example the National Policy Statements) are likely to have the same implications as Scotland (see Section 8.2.2).

away. This is significant since the ENSG (2009) report states that key works highlighted in Table 8.8 should have commenced immediately with a target completion date of 2018.

However, planning is only one of the reasons for such delay. Part A of figure 8.4 (page 392) also highlights major constraints which have the potential to delay or even cause the with-drawl of renewable projects: three of the four constraints listed here (planning, grid, supply chain and financial) have acted as significant delays and/or barriers to renewable energy deployment in Scotland and the UK. In addition, Table 8.10 (page 393) shows the average time taken from receiving positive determination (planning consent) to commissioning (operation) in the UK for onshore wind. This data is also broken down to the sub-national level (England and Scotland) and for >50 MW projects and <50 MW projects. In contrast to the time reduction over the same period in receiving a planning decision, the average time from receiving planning consent to commissioning in the UK has increased. As Table 8.10 shows, this has almost doubled for both <50 MW and >50 MW projects at the UK level during the period 2007 and 2012. When Scotland and England are examined separately, although both show increases in the average time taken, the increase is significantly higher in England. The average trend in Scotland since 2008 is one of more-or-less stability around 30 months. In contrast, the trend for England since 2008 is more erratic, exhibiting annual variations although the overall trend is one of increasing time with a significant increase during 2012. A key point to be drawn from Table 8.10 is that there are additional barriers to large-scale RES-E deployment in the UK post-planning consent: the electricity network is certainly a barrier to deployment. In addition to the barriers discussed previously in chapter seven. Section 8.5 will examine policy risk and uncertainty as a barrier.

There are two additional reasons for the delays in the proposed transmission work: technological risk and supply chain risk. Technology risk is important for both the transmission work and the generating technologies to be connected. This risk category is more significant for offshore deployment (Wood, 2010). Typically the electrical

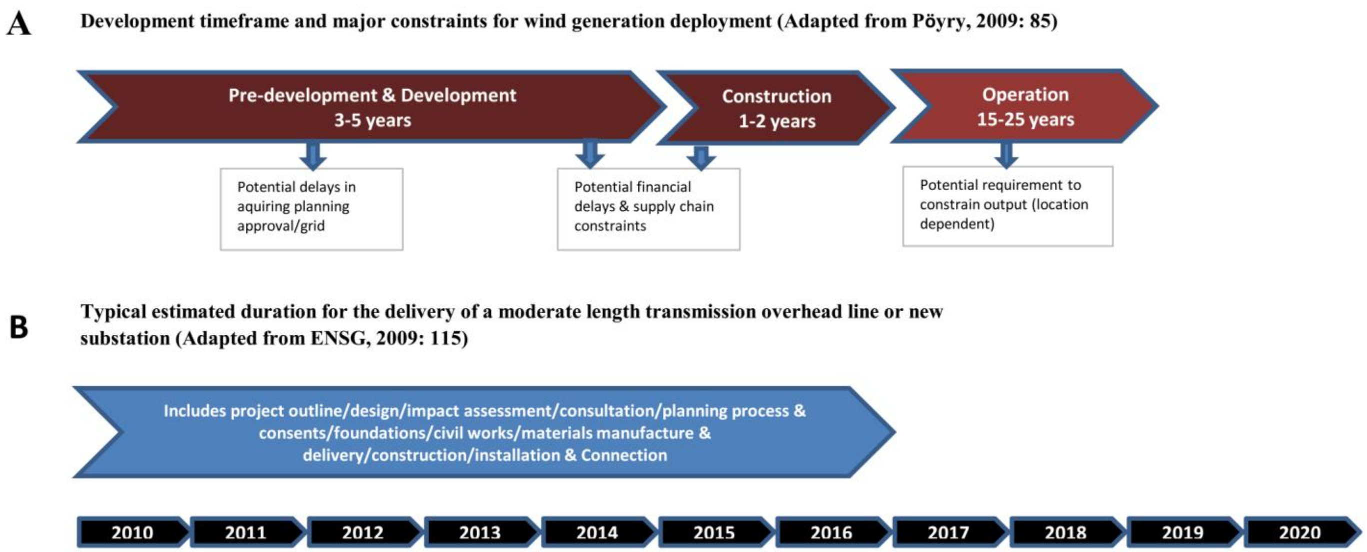


Figure 8.4 Average development timeframe for a 50 MW onshore wind farm (A) and average duration for the delivery of a transmission line or new substation (B)

Table 8.10 Average time (months) from consent to commissioning for onshore wind farms in the UK, Scotland and England – 2007 to 2012

	UK		Scotland		England	
	s36	non-s36	s36	non-s36	s36	non-s36
2007	20.4 (1)	21.2 (27)	-	19.8 (14)	20.4 (1)	28.6 (7)
2008	25.1 (3)	29.1 (39)	36.3 (1)	29.5 (21)	-	27.2 (13)
2009	41.1 (2)	26 (39)	43.5 (1)	26.9 (13)	38.7 (1)	24.1 (16)
2010	26.9 (1)	32 (38)	-	28.4 (11)	26.9 (1)	33 (25)
2011	40.8 (3)	29 (47)	-	30.1 (24)	36.2 (2)	29.6 (14)
2012	49 (1)	38 (24)	-	30.3 (11)	49 (1)	46.4 (7)

SOURCE: Renewable Energy Planning Database (REPD) (DECC, 2012b).

connection to shore from the offshore renewable development uses high-voltage alternating current (HVAC) technology at 132kV. However, as offshore wind farms move further from shore (later Round 2 and Round 3 projects located more than 60-80km offshore), the longer cable distances required result in unacceptable losses. In contrast, with significantly longer cables permitted by reducing subsea transmission cable losses, high-voltage direct current (HVDC) technology has become the preferred offshore transmission technology (National Grid, 2010). There are, however, a number of issues: subsea HVDC technology is still being developed; such innovative technologies are associated with high capital costs and the market for HVDC cables and associated technology, including voltage source converters (VSC) and static var compensations (VAR) are still at an embryonic stage; HVDC systems are much heavier than alternative technologies, increasing the level of difficulty or risk in deploying in an offshore location; limited experience results in a lack of understanding of the technical, commercial and environmental issues associated with such technologies (ENSG, 2012; Wood and Taylor, 2012). Supply chain risk is also relevant, given the current and future scale of offshore transmission work required not just across the UK but in Europe and beyond with the increasing deployment of offshore renewables (Elliott, 2010). It is estimated that approximately 7,500km of HVDC cable will be required in the UK by 2020 to connect up all the offshore projects planned: however, in 2010 current global HVDC cable production was around 1,000km per annum (ECCC, 2010).

There are also technology and supply chain risks for offshore renewable technologies, particularly for wave and tidal stream devices. Marine renewables are at the emergent stage: they are typically small and medium-sized companies developing a specific device (although this is changing with the entry of large-scale companies, including multi-national utilities). Actual marine deployment is associated with significant costs due to the harsh environmental characteristics which are typically found at the more optimum locations for wave and tidal devices. In addition, there are costs related to the need for specialised equipment and vessels, an appropriate weather window for installation and competition with other offshore industries (not just oil and gas, but increasingly from wind power). In summary, the marine renewables industry faces relatively high costs and high risk. Although some of these risks are faced by offshore wind development, there are a number of critical differences between marine renewables and offshore wind, primarily the increased level of technological and finance risk: will the technologies come through quickly enough and de-risk enough to obtain finance?

It is important to remember that currently within marine renewables, there are no clear '*winning*' devices, some of the technologies chosen to deploy commercially at the Pentland Firth and Orkney Waters are very small devices having only been connected at the European Marine Energy Centre (EMEC).[312] Technical and financial problems resulted in the indefinite closure of what was the world's first commercial wave power project at Aguçadoura in Portugal with 2.25 MW installed capacity of Pelamis devices – despite aims to increase capacity to 21MW (Clean Tech, 2009). Also, can the supply chain be ramped up enough? If Pelamis is to meet its proposed 400 MW capacity installation, this would require the construction of a machine every week until 2020 (Andrew Scott, personal communication). Due to the level of high-risk for marine renewables, this could act as a major barrier. This is particularly the case given current economic conditions. In addition, with the massive program of offshore wind farms just starting (not to mention the growth of onshore wind farms occurring in close proximity), there is a danger that wave and tidal might lose out. If large-scale developments are deemed by investors to be too high-risk, this could see a leakage of finance to smaller projects as investors seek to gain more confidence in the sector. Because wind power does not have this level of technological risk, finance could also concentrate on this area to the expense of marine renewables. In short, it is likely that marine renewables are likely to be a victim of a high attrition rate with regard to projects.

Key transmission network delays can also have further implications for renewable generators. Such delays could: negatively impact on investor/developer confidence with resultant impacts on both the access to, and the cost of finance for generating projects; push generation projects beyond the proposed 2017 cut off date for the Renewables

[312] Established in 2003, EMEC is the first and only purpose-built, accredited open sea testing facility for developers of both wave and tidal energy converters. Based in Orkney, EMEC has 14 full-scale test berths with grid connection to the mainland transmission system (EMEC, 2012).

Obligation/Contracts for difference feed-in tariff. This would effectively remove the choice of subsidy mechanism support due to network delays beyond their control;[313] potentially increase the costs of compensation under the '*connect and manage*' scheme (see section 8.4.22). Critically, delays could serve to increase the difficulty in attempts to correlate the development of both renewable and transmission network projects.

The issues discussed above, although focused on Scotland and the interface with England, are equally valid for the development of the transmission network across the rest of England and Wales. Overall, in addition to the 11.3GW of additional generation that can be accommodated by the proposed or current transmission works in Scotland (see table 8.8), around 4.2GW and 23.8GW could be accommodated by similar transmission work proposals in Wales and England, respectively (ENSG, 2012). Although a sizeable proportion of this capacity is for non-renewable generation (primarily gas, interconnector capacity and potentially new nuclear), it is worth looking briefly in more detail at the renewable capacity anticipated for these two countries.[314]

The Irish Sea Round 3 offshore wind farm (4.2GW) is licensed for Wales, requiring a 2GW HVDC cable in addition to a number of key transmission works onshore: reconductoring of a number of existing lines, extension and modification of a number of substations (Pentir, Wylfa and Pembroke) and two new transmission lines (Pentir-Wylfa double circuit and single circuit). The Mid-Wales transmission area currently does not have any existing transmission infrastructure. However, 400MW of onshore wind already have a signed offer to connect with an additional 360MW expected to connect by 2015/16. This would require the construction of three new substations and a new 400kV transmission link. The English East Coast and East Anglia area is of particular interest with regard to England due in large part to the proposed generation connections coming from the three largest potential offshore wind developments with a combined capacity of up to 23.2GW: Dogger Bank (9,000-12,000MW); Hornsea

[313] However, this would depend on the grace period (see chapter seven).

[314] The following information for Wales and England is based primarily on the ENSG 2012 report.

(4,000MW); and East Anglia (7,200MW) (Wood and Taylor, 2012).[315] This would require significant onshore and offshore transmission infrastructure deployment, including new transmission links (overhead and HVDC), new substations and the upgrading and/or reconductoring of existing grid. As with Scotland, this scale of work has significant implications with regard to the external failures examined here (planning, electricity transmission network, public participation and engagement and policy risk/uncertainty) in addition to issues of timing (with generation assets) and supply chain risk.

8.4.2 The UK Electricity Transmission Network: Access and Allocation of Capacity

Increasing the physical capacity of the transmission system, however, is not an immediate measure with regard to shortening the queue of generating plant awaiting connection. In addition, the option for generating infrastructure to connect is often dependent on a number of key stages being completed in the correct sequence. As discussed in the previous section, delays in improving transmission capacity are occurring with further delays projected. Such barriers impact on the need for renewable developments to be able to export their electricity to the market and, critically to receive subsidy via the RO mechanism. In other words, obtaining grid access can be said to improve the attractiveness to investors and developers. The Transmission Access Review (TAR) report set out a number of reforms to remove such access barriers for generators in order to both speed up the connection of new generation and to the deployment of new transmission capacity (OFGEM, 2008a). In particular, there are two reforms of interest: the '*connect and manage*' (C&M) model and the '*Revenues=Incentives+Innovation+Outputs*' (RIIO) model for transmission price controls.

The C&M model, initially introduced as a short-term or *interim* measure to allow faster connection of some renewable generation from May 2009 was adopted as an enduring

---

[315] This is in addition to a number of smaller offshore wind farm developments (Round 2), proposed new gas-fired generation and potential new nuclear power stations.

solution from August 2010.[316] The C&M model replaced and differed from the previous Invest and Connect (IC) model by allowing the temporary relaxation of connection rules to and use of the network without the need for generators to wait until wider system reinforcements are complete. NGET will manage any constraints issues this approach will cause to the network. As OFGEM (2008b: 2) states:

> "*The underlying principle* [of connect and manage] *is that generation would acquire firm access rights from a particular date and be allowed to generate or receive compensation from that date, subject to local* [enabling] *works completion* [and] *generating plant commissioned and available.*"[317]

The C&M model is aimed at providing sustained and viable connection opportunities and firm connection dates reasonably consistent with project development timescales with all constraints costs including costs arising from the advanced connection to be socialised equally among all generators and suppliers on a per-MWh basis (DECC, 2010b).[318] The approach, then, would provide renewable developers the confidence to construct generating plant prior to the completion of the transmission works.

In contrast, under the previous invest and connect system, new plant had to join the access queue on a first come first served basis and wait for all the relevant reinforcement of the wider network to be completed. On implementation of the C&M model, it was originally anticipated that at least 450 MW of renewable generation (basically small and large wind farms) would connect under I&C model over the next 2-3 years in Scotland with the scope to advance a further 1.6 GW contingent on

[316] The C&M model provides equal access rights for new and existing contracts for all types of generation (it is open to all types of electricity generating plant and not just renewables.

[317] Enabling works are the minimum transmission works needed to connect a generator to the transmission network. In contrast, wider system works refers to other transmission works associated with increasing the capacity of the network to accommodate large changes in generation or demand and to comply with security standards (OFGEM, 2012e).

[318] The C&M model also increases the amount of time users must commit to the network (at their current specified capacity) from one to two years, thus contributing to transmission investment more effectively and providing a stronger, more stable signal to support network investment which is the long-term solution to network constraint and constraint costs. In other words, the more projects are brought on to the transmission network, the more guarantee of long-term funding in order to improve confidence and thus capacity building of the transmission system.

developers to accelerate plans. As of the end of 2012, 129 renewable projects accounting for 28,478 MW have received advances in transmission connection dates averaging 6 years (National Grid, 2013). Of this, 490 MW (1.7 per cent of the total offered earlier connection dates) have already been connected early by an average of 7 years. At the sub-national level, 53 per cent of all projects are located in Scotland with 61 per cent of these in the SHETL (north of Scotland) area. Interestingly, 96 per cent of all projects are renewables.[319]

It is clear that one of the benefits of the CM model, so far, is that it has reduced the average waiting time for developers although this is not a guarantee that the generation plant will be connected by that date. This leads to two major complementary concerns with this particular approach. Firstly, provided a developer has been offered a connection agreement under the C&M approach, the risk in not actually being connected is mitigated by the provision of compensation. This removes the element of anticipation between the location of the generation and transmission infrastructure due to the lack of an efficient investment signal. In other words, there is the risk that generation plant could be built in areas where transmission infrastructure will be delayed or not constructed. With particular emphasis on onshore wind, the C&M model also fails to take into account the attributes of different generation. Given the delays already in evidence, this should already be a significant and increasing concern.

Secondly, the adoption of this approach would appear to be at the expense of achieving the connection uptake at total low cost: OFGEM point out the constraint costs (the compensation to generators if the transmission capacity is not provided on time) could be around £50 million for the first year of C&M operation (2009-10), out of total constraint costs of approximately £250 million (OFGEM, 2009a). However, if transmission investment does not keep pace with the growth in generation (and it is important to remember that the C&M model is already delivering accelerated connections at the cost of increased congestion and constraint costs, external barriers to

[319] Interestingly, 96 per cent of all projects are renewables (out of a total of 32,126 MW offered earlier connection agreements.

the increasing transmission capacity could still delay or even stop required development (for example, planning).[320]

Of concern, the bulk of C&M connection agreements are located within Scottish transmission network and the northern area in particular and this is one of the most heavily constrained UK network regions with the added pressure that a significant volume of renewable generation is required to be connected there in order for the 2020 targets to be met. If the development of the transmission system in line with renewable aspirations is unable to keep pace with demands for new capacity, constraint costs are expected to rise significantly with customers picking up a substantial proportion of the additional constraint costs (OFGEM, 2009b). Additional studies modelling future constraint cost levels range from over £350 to £500 million per annum (Frontier Economics, 2009). This cost is dependent on whether the transmission companies deliver the key transmission works to the agreed schedule which has already evidence slippage to around £600 million per annum according to National Grid. Despite new transmission investment, costs are predicted to remain high until 2017/18 and beyond (Frontier Economics, 2009). In addition, under the new changes, if there are a number of new connections contingent upon the same enabling works they will be treated on a 'first come, first served' basis. Therefore although many respondents to the consultation 'considered it logical' to expect that the socialised C&M model would lead to higher constraint costs due to the inefficient siting of plant in network terms, it comes as no surprise that those with significant generation interests in Scotland tended to view the cost impacts of the SCM most favourably (DECC, 2009).

Interestingly, although the C&M system has been shown, under modelling, to facilitate the UK to potentially meet around 30 per cent of RES-E generation by 2020 (in line with the government's sectoral target for electricity) the level of constraints costs differs depending on the analysis and modelling considered. Redpoint's report 'I*mproving Grid Access: Modelling the Impacts of the Consultation Options*' for the Department of Energy and Climate Change (DECC, 2010a) showed constraints costs significantly lower than

[320] The connect and manage system was only ever viewed as a temporary measure (i.e. interim).

expected in comparison to alternative studies by others (see above). Redpoint's 'central scenario' of incremental constraint costs for the C&M is estimated at £195 million for the 2010-2020 period – or only £18 million per annum. In contrast, recent analysis by Frontier Economics on behalf of OFGEM stated potential total constraint costs of £3.5 billion with National Grid's estimates even higher (Frontier Economics, 2009).[321] Even Redpoint's 'high scenario' assuming maximum feasible wind deployment and a two-year delay in network investment leads to constraint costs of around £1 billion by 2020 or £1 per annum per household average electricity bill (DECC, 2010a). However, DECC has stated its confidence that the Redpoint modelling and analysis is more sound that those proposed by both OFGEM (the independent regulator) and National Grid, despite the Redpoint (DECC, 2010a: 6) report stressing that

> "*our constraint cost results – even in the C&M Socialised High SG scenario* [the C&M 'high scenario', see above] – *should not be treated as an 'upper bound' on potential outrun costs... we have not attempted to model the impact of unforeseen external events, market power, strategic investment decisions or broader policy and regulatory changes on transmission congestion.*".

Building on the '*RPI-X@20*' review of energy network regulation, OFGEM has introduced the RIIO model for transmission price control (OFGEM, 2010b). The '*Revenues=Incentives+Innovation+Outputs*' (RIIO) model is essentially a stakeholder-based model adopted to provide transmission and distribution companies with the incentives to invest in the provision of the transmission infrastructure necessary to meet energy sustainability and low carbon targets and at low cost for consumers (OFGEM, 2010c).[322] In essence, the RIIO model will extend the transmission price control period from five to eight years with clear outputs (including secondary objectives) and in-built reward and penalty mechanisms depending on the performance of the transmission company with regard to the outputs. The first RIIO transmission price control period (RIIO-T1) will commence in 2013 and run until 2021/22. RIIO-T1

---

[321] The disparities are acknowledged in DECC's Impact Assessment '*Proposals for improving grid access*' (DECC, 2010b).

[322] The RIIO model will apply across both the electricity and gas transmission and distribution networks (OFGEM, 2010c).

has recently set out £22 billion in investment plans, of which around £15 billion would include investment in the electricity sector in England and Wales and £7 billion in Scotland (OFGEM, 2012f).

Although the RIIO model introduces strong elements of stakeholder involvement and sustainable energy objectives are '*mainlined*' into the transmission price control process there are a number of concerns with regard to the challenge of substantially increasing network capacity in line with the renewable targets. Extending the price control period introduces an element of risk given the uncertainties involved. Although a mid-term review mechanism has been included, by increasing flexibility in the process there is the real risk that RIIO could incentivise the delivery of transmission assets that are either not required (stranded) or where the capacity is under-utilised. RIIO does adopt safeguard requirements to avoid this possibility (including the publication of up-front business plans and providing justification (the needs case) for proposed works:

> "*Our proposals are intended to ensure there is enough flexibility and certainty in the price control settlement to allow NGET to meet any changes in the generation and demand background. At the same time our proposals will also protect consumers by ensuring they only pay for new infrastructure that is needed (i.e. reduced risk of stranded assets) and that NGET faces strong incentives to deliver WW* [Wider-Works] *outputs efficiently and innovatively. We believe these arrangements for WW outputs represent an appropriate balance of risk sharing between NGET and consumers.*" (OFGEM, 2012e: 23)

However, no matter the level of safeguards put in place, there is significant uncertainty involved with regard to the timing, volume and location of generation and renewable generation in particular. In addition, there are a number of barriers out-with the design of RIIO and the control of OFGEM that could delay the deployment of both transmission and generation infrastructure. These include planning, supply chain and public opposition. When the 'connect and manage' model is included in the system, there is a real concern that the situation might arise where transmission infrastructure is being deployed without generation assets to connect to, and vice-versa at least for an indeterminate period of time. This can and has occurred prior to RIIO and connect and manage; the issue is whether both models will aggravate the situation.

References

Boyle, G. 2004. *Renewable Energy: Power for a Sustainable Future*. Oxford University Press: Oxford.

Clean Tech, 2009. Pelamis sinks Portugal wave-power project [online] Available from http://cleantech.com/news/4276/pelamis-sinks-portugal-wave-power-p

Communities and Local Government, Department for the Environment, Food and Rural Affairs, Department of Trade and Industry and the Department for Transport, 2007. Planning for a Sustainable Future – White Paper: May 2007 [online] Available from http://www.official-documents.gov.uk/document/cm71/7120/7120.pdf

Crown Estate, 2010. Offshore Wind Energy [online] Available from http://www.thecrownestate.co.uk/offshore_wind_energy

Crown Estate, 2012a. Rounds 1 & 2 [online] Available from http://www.thecrownestate.co.uk/energy-infrastructure/offshore-wind-energy/our-portfolio/project-details/rounds-1-2/

Crown Estate, 2012b. Wave and Tidal – Our portfolio [online] Available from http://www.thecrownestate.co.uk/energy-infrastructure/wave-and-tidal/our-portfolio/

Crown Estate, 2013. Offshore Wind: Rounds 1 and 2 wind farms [online] Available from http://www.thecrownestate.co.uk/energy-infrastructure/offshore-wind-energy/our-portfolio/

Department of Energy and Climate Change, 2009. Initial summary of consultation responses by question [online] Available from http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Consultations%5CImproving%20Grid%20Access%5C1_20091217112809_e_@@_summaryConsultationResponses.pdf&filetype=4

Department of Energy and Climate Change, 2010a. Improving Grid Access – Technical consultation on the model for improving grid access: Consultation Document 3 March 2010 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/improving_grid/improving_grid.aspx

Department of Energy and Climate Change, 2010b. Impact Assessment: Proposals for improving grid access – IA No: DECC 0008 – 27/07/2010 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42975/253-improving-grid-access-ia.pdf

Department of Energy and Climate Change [DECC], 2011a. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change (DECC), 2011b. Updated Energy and Emissions Projections 2011: URN 11D/871 – October 2011 [online] Available from http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf

Department of Energy and Climate Change [DECC], 2011c. National Policy Statement for Electricity Networks Infrastructure (EN-5) – July 2011 [online] Available from https://whitehall-admin.production.alphagov.co.uk/government/uploads/system/uploads/attachment_data/file/37050/1942-national-policy-statement-electricity-networks.pdf

Department of Energy and Climate Change (DECC), 2011d. UK Renewable Energy Roadmap – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change (DECC), 2011e. Overarching National Policy Statement for Energy (EN-1) – July 2011 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf

Department of Energy and Climate Change [DECC], 2012a. Energy Networks Strategic Group – Role of the Group [online] Available from https://www.gov.uk/government/policy-advisory-groups/electricity-networks-strategy-group

Department of Energy and Climate Change [DECC], 2012b. Planning database Project: Wind Onshore [online] Available from https://restats.decc.gov.uk/app/reporting/decc/monthlyextract

Department of Trade and Industry [DTI], 2006. The Energy Challenge: Energy Review – A Report – July 2006 [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/energy/whitepaper/review/page31995.html

Energy and Climate Change Committee [ECCC], 2010. The future of Britain's electricity networks – Volume I – 23 February 2010 [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenergy/194/194.pdf

Electricity Networks Strategy Group, 2009a. ENSG 'Our Electricity Transmission Network: A Vision for 2020' Full Report [online] Available from http://www.ensg.gov.uk/assets/ensg_transmission_pwg_full_report_final_issue_1.pdf

Electricity Networks Strategy Group, 2009b. ENSG 'Our Electricity Transmission Network: A Vision for 2020' – Addendum Report: Further Analysis – 2030 Generation and Demand Scenarios – URN:09/715 – July 2009 [online] Available from http://webarchive.nationalarchives.gov.uk/20100919181607/http:/www.ensg.gov.uk/assets/ensg__2030_transmission_addendum_final_issue_1.pdf

Elliott, D. 2010. Sea Power – How We Can Tap Wave and Tidal Power In, D. Elliott (ed) Sustainable Energy: Opportunities and Limitations: 66-83. Palgrave Macmillan

Energy Networks Strategic Group [ENSG], 2012. Our Electricity Transmission Network: A Vision For 2020 - An updated full report to the electricity networks strategy group on the strategic reinforcements required to facilitate connection of the generation mix to the Great Britain transmission networks by 2020 – February 2012: URN:11D/954 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48274/4263-ensgFull.pdf

Energy Networks Strategic Group [ENSG], 2013. Transmission Owner major projects: status update – March 2013 [online] Available from https://www.gov.uk/government/policy-advisory-groups/electricity-networks-strategy-group

European Marine Energy Centre, 2012. EMEC – About Us [online] Available from http://www.emec.org.uk/about-us/

Frontier Economics, 2009. Connect and manage costs under different bidding packages: A slide pack for Ofgem – 12 June 2009 [online] Available from http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/tar/Documents1/TAR%20-%20Frontier%20Congestion%20Analysis%20-%20FINAL.pdf

Greenpeace, 2005. Decentralising Power: An Energy revolution for the 21st Century [online] Available from http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7154.pdf

Lawton, P. 2009. Whither the UK Electricity Grid? – Summary: The Grid in 2030 – a change of environment [online] Available from http://www.worldenergy.org/documents/lawton__summary_1.pdf

National Audit Office [NAO], 2012. Offshore electricity transmission: a new model for delivering infrastructure – June 2012: Appendix 3 [online] Available from http://www.nao.org.uk/report/offshore-electricity-transmission-a-new-model-for-delivering-infrastructure/

National Grid, 2009. GB Seven Year Statement 2009 [online] Available from http://www.nationalgrid.com/uk/sys_09/default.asp?sNode=SYS&action=&Exp=Y

National Grid, 2010. Round 3 Offshore Wind Farm Connection Study – Version 1.0 [online] Available from http://www.thecrownestate.co.uk/media/214799/round3_connection_study.pdf

National Grid, 2011. ODIS – Offshore Electricity Transmission: Possible Options for the Future – Offshore Development Information Statement: September 2011 [online] Available from http://www.nationalgrid.com/uk/Electricity/OffshoreTransmission/ODIS/CurrentStatement/2011docs/Agree/

National Grid, 2012. UK Future Energy Scenarios – UK gas and electricity transmission – September 2012 [online] Available from http://www.nationalgrid.com/NR/rdonlyres/332FFA28-6900-4214-92BB-D3AD4FA5DC01/56611/UKFutureEnergyScenarios2012.pdf

National Grid, 2013. Quarterly Report on the Connect and Manage Regime – 01 September 2012 – 31 December 2012 [online] Available from http://www.nationalgrid.com/NR/rdonlyres/C58A2961-91C5-49C4-ADCC-302AE8F4FC04/58783/ConnectandManageQuarterlyReport010912to311212v1.pdf

National Grid and the Crown Estate, 2011. Offshore Transmission Network Feasibility Study – 26 September 2011: Version 1.0 [online] Available from http://www.nationalgrid.com/NR/rdonlyres/4FBE15A0-B244-4BEF-87DC-8D0B7D792EAE/49346/Part1MainBodysection191.pdf

Office of Gas and Electricity Markets [OFGEM], 2008a. Transmission Access review – Final Report: Ref: Ofgem (89/08), BERR (URN 08/1020): 26 June 2008 [online] Available from http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/tar/Documents1/080626_TAR%20Final%20Report_FINAL.pdf

Office of the Gas and Electricity Markets [OFGEM], 2008b. Connect & Manage [online] Available from http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/tar/Documents1/Connect%20and%20Manage_PHIL.pdf

Office of the Gas and Electricity Markets [OFGEM], 2009a. Delivering future energy networks – OFGEM Presentation to the All Energy Conference: Stephen Smith [online] Available from http://www.all-energy.co.uk/userfiles/file/Stephen_Smith_200509.pdf

Office of the Gas and Electricity Markets [OFGEM], 2009b. Enduring Transmission Reform [online] Available from http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/tar/Documents1/Enduring%20Transmission%20Access%20Reform%20FINAL%20PUBLISHED.pdf

Office of Gas and Electricity Markets [OFGEM], 2010a. Project Discovery: Options for delivering secure and sustainable energy supplies – Consultation: Ref: 16/10: 3 February 2010 [online] Available from http://www.ebso.org.tr/b2b/ebsodergi/resimler/OFGEM_Project_Discovery_FebConDoc_FINAL.pdf

Office of Gas and Electricity Markets [OFGEM], 2010b. RIIO: A new way to regulate energy networks: Final decision – October 2010: Reference: 128/10 [online] Available from http://www.ofgem.gov.uk/Networks/rpix20/ConsultDocs/Documents1/Decision%20doc.pdf

Office of Gas and Electricity Markets [OFGEM], 2010c. Handbook for implementing the RIIO model – 4 October 2010 [online] Available from http://www.ofgem.gov.uk/Networks/rpix20/ConsultDocs/Documents1/RIIO%20handbook.pdf

Office of Gas and Electricity Markets [OFGEM], 2012a. RIIO Update – Issue 02 – July 2012 [online] Available from http://www.ofgem.gov.uk/Networks/PriceControls/newsletter/Documents1/RIIO%20newsletter%20July%202012%20Issue%20Two_WEB.pdf

Office of Gas and Electricity Markets [OFGEM], 2012b. Offshore transmission - Enduring tenders [online] Available from http://www.ofgem.gov.uk/Networks/offtrans/et/Pages/et.aspx

Office of Gas and Electricity Markets [OFGEM], 2012c. Round one transitional tenders [online] Available from http://www.ofgem.gov.uk/Networks/offtrans/rott/Pages/rott.aspx

Office of Gas and Electricity Markets [OFGEM], 2012d. Round two transitional tenders [online] Available from http://www.ofgem.gov.uk/Networks/offtrans/rttt/Pages/rttt.aspx

Office of Gas and Electricity Markets [OFGEM], 2012e. RIIO-T1: Initial Proposals for National Grid Electricity Transmission and National Gas Grid: Reference: 104/12 – 27 July 2012 [online] Available from http://www.ofgem.gov.uk/Networks/Trans/PriceControls/RIIO-T1/ConRes/Documents1/RIIO%20T1%20NGGT%20and%20NGET%20Cost%20assessment%20and%20uncertainty.pdf

Office of Gas and Electricity Markets [OFGEM], 2012f. Press Release: OFGEM consults on "22 billion investment plans to upgrade Britain's gas and high voltage electricity networks – Monday 16 July 2012 [online] Available from http://www.ofgem.gov.uk/Media/PressRel/Documents1/20120716_RIIO_Press_Release.pdf

Office of Gas and Electricity Markets [OFGEM] and the Department of Energy and Climate Change [DECC], 2012. Offshore Transmission Coordination Conclusions Report – 1 March 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/39287/4486-offshore-transmission-coordination-project-conclus.pdf

Pollitt, M. 2010. Oral evidence taken before the Energy and Climate Change Committee – Wednesday 1 April 2009: The Future of Britain's Electricity Networks – Vol II – 23 February 2010 [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenergy/194/194ii.pdf

Pöyry, 2009. Timeline for Wind Generation to 2020 and a Set of Progress Indicators: A report to the Committee on Climate Change July 2009 [online] Available from http://hmccc.s3.amazonaws.com/docs/503_WindTimelinesProgressIndicators_v7_0.pdf

Redpoint, 2011. Coordination in Offshore transmission – an assessment of regulatory, commercial and economic issues and options – A report by Redpoint Energy Limited – December 2011: Version: FINAL Date: 15/12/11 [online] Available from http://www.ofgem.gov.uk/Networks/offtrans/pdc/pwg/OTCP/reports/Documents1/Offshore%20Transmission%20Redpoint%20Report%20-%2015-12-2011.pdf

Redpoint and TNEI, 2013. Scottish Islands Renewable Project: Final Report for DECC/Scottish Government – 14/05/2013 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/199038/Scottish_Islands_Renewable_Project_Baringa_TNEI_FINAL_Report_Publication_version_14May2013__2_.pdf

Scottish and Southern Energy, 2012a. Dounreay-Beauly [online] Available from http://www.sse.com/DounreayBeauly/

Scottish and Southern Energy, 2012b. Beauly to Kintore [online] Available from http://www.sse.com/Beaulykintore/

Scottish Government, 2010. Beauly-Denny upgrade approved – January 6, 2010 [online] Available from http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Infrastructure/Energy-Consents/Beauly-Denny-Index

Select Committee on European Union, 2008. European Union – Written Evidence: Session 2007-08 [online] Available from http://www.publications.parliament.uk/pa/ld200708/ldselect/ldeucom/175/175we01.htm

TNEI and PPA Energy, 2011. Offshore Transmission Coordination Project – Final Report for the Asset Delivery Workstream – 20th December 2011 [online] Available from http://www.ofgem.gov.uk/Networks/offtrans/pdc/pwg/OTCP/reports/Documents1/TNEI-7098-03-Asset%20Delivery%20Workstream-Release-15-12-2011.pdf

Watson, J. 2010. Oral evidence taken before the Energy and Climate Change Committee – Wednesday 1 April 2009: The Future of Britain's Electricity Networks – Vol II – 23 February 2010 [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenergy/194/194ii.pdf

Watson, J., Scrase, I. and Stapleton, L. 2010. Transforming the UK's Energy System: Policies for the 2020 Renewables Target and Beyond – A Report for Friends of the Earth [online] Available from http://www.foe.co.uk/resource/briefings/transforming_uk_energy.pdf

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee.

Wood, G. and Dow, S. 2011. *What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy*. Energy Policy 39(2011): 2228-2244.

Wood, G. and Taylor, A. 2012. Offshore Wind - A Position paper: A Report for the Offshore Renewables Institute – December 2012.

8.5 Policy risk

Subsequent targets for renewable electricity generation (RES-E) have been set over the years, with each new target increasing the required level of generation (Gross and Heptonstall, 2010). In addition, the devolved administrations have established sub-national targets. With a target to deliver 100 per cent of electricity equivalent to total electricity consumption by 2020 equating to around 16-17GW installed capacity, Scotland has by far the most demanding target (Scottish Government, 2011a).[323] It is clear that the adoption of the various targets have increased the level of the scope, ambition and challenges facing renewable electricity deployment. This can be seen by the adoption of three subsidy mechanisms over the last two decades: the Non-Fossil Fuel Obligation (NFFO), the Renewables Obligation (RO) and the reformed Renewables Obligation (rRO). A new mechanism, the Contracts for Difference Feed-in Tariff (CfD FIT) is proposed to enter the renewable electricity generation landscape in 2014. As such,

> "*The increasing evidence for anthropogenic climate change, together with concerns about the security of energy supplies had led many governments to re-examine their energy policies – and to make significant changes. The UK is no exception… Policy activity has accelerated almost breathlessly, with a succession of White Papers, consultations, Acts of Parliament and new institutions.*" (Pearson and Watson, 2012: 2).

UK renewable electricity policy needs to create the conditions conducive to attain the substantial level of investment required to meet the sectoral target. This requires a clear, stable and transparent long term signal to investors in order for them to invest in, and ultimately deploy and operate the various renewable generation assets and associated infrastructure such as transmission and distribution networks. Policy also needs to achieve this whilst alleviating the burden on consumers (both financial and non-financial). Changes in policy, whether new policy initiatives and/or interventions, are also necessary: there is always a need to refine current approaches in light of evidence derived from on-going programmes and lessons learnt (Wood and Dow, 2011;

[323] Scotland has also set an overall renewables target (all sectors) of 30% by 2020 (Scottish Government, 2011b). In contrast, the Northern Ireland Executive has a target to deliver 40% RES-E by 2010 whilst the Welsh Assembly have indicated a target of 4GW (DECC, 2011a).

Woodman and Mitchell, 2011). Circumstances also change, particularly in the energy sector.[324]

In addition, policy is rarely designed on a blank slate. This is particularly the case in the energy sector where investment assets are typically long-lived. Generating plant (and network infrastructure) will be in operation through periods characterised by different circumstances, contexts and governments, and priorities will inevitably change. In particular, renewable electricity technologies require state support to varying degrees at least for the foreseeable future. With the plethora of policy initiatives and interventions, however, there is the issue of policy risk:

> "*Where a project's financial viability is reliant on policy interventions, such as… the Renewables Obligation, developers are exposed to the risk that policy may change and undermine the economics of their project.*" (Committee on Climate Change [CCC], 2011: 64).

In particular, policy uncertainty can derive from the occurrence of regulatory changes in policies, with regulatory changes affected by the economic efficiency and financial sustainability of the policy, the coherence of the policy and whether or not the policy objectives are likely to be successful (Agnolucci, 2008). In the UK, however, policy risk has been viewed as a significant and contiguous barrier to renewable deployment from virtually the inception of government-led support (Mitchell, 1995; Wood, 2010; Wood and Dow, 2011). In an analysis of policy risk almost ten years ago, Mitchell and Connor (2004: 1935 and 1946) stated that:

> "*The UK's renewable energy policy has been characterised by opportunism… and continuous adjustments… policies continue to require adjustments and renewables delivery continues to be undermined.*"

[324] The quote from Pearson and Watson (2012) highlights this: for a detailed account of the changes in UK energy policy in recent history, see Helm (2008).

8.5.1 Policy reviews, reforms and policy risk

It is clear from Table 8.11 (pages 413-414) that there has been almost ceaseless modification to the two previous and the current subsidy support mechanism. The key policy risks highlighted here show that the opportunistic nature of UK renewable electricity policy continues. In addition, there have been both positive and negative policy decisions. In particular, there are three main categories of UK RES-E policy risk: priorities; targets; and reviews and reforms. Although the previous NFFO and (non-reformed) RO mechanisms have been previously discussed[325], it is worth reiterating the key points relevant to policy risk, in particular for the Renewables Obligation in both its non-reformed (2002-2009) and reformed states (2009 onwards).

8.5.1.1 Priorities

Since the early 1990s, the UK has adopted a least-cost approach based on competitive and market-based policies. As discussed elsewhere in this thesis, this means that the *de facto* priority of UK energy policy was that decisions should be left to the liberalised energy market. Competition, then, would drive innovation and deployment of infrastructure based on the economic goal of choice by price within markets (Mitchell (2008). As Rutledge and Wright (2010: 18) put it:

> "*Instead of regulation being used to control and circumscribe the operation of markets, henceforth regulation would be used to create markets – to inject markets and market-type mechanisms into every nook and cranny of the UK's gas and electricity industries – to give it a name, we might call it 'Regulation for Competition'*"

This approach has been repeatedly reiterated in various UK energy policy documents over the years, in particular: the Performance and Innovation Unit (PIU) 2002 '*The Energy Review*'; the 2006 '*The Energy Challenge: Energy Review*';

[325] The previous NFFO and (non-reformed) RO mechanisms have been previously discussed (in particular see chapter three.

Table 8.11 Key policy risks for the Non-Fossil Fuel Obligation (NFFO), Renewables Obligation (RO) and reformed Renewables Obligation (rRO)

Non-Fossil Fuel Obligation (NFFO)	
1990	NFFO comes into force. NFFO round 1. Prices set by cost justification. Uncertainty over process (e.g. contract lengths; cost methodologies; confusion over management role (between Department of Energy, Regional Energy Companies, Non-Fossil Purchasing Agency and the Office of Electricity Regulation).
1991	NFFO round 2. Prices set by competitive bidding (tender process) with contractors offered a strike price rather than bidding price. Competitive bidding resulted in waves of development and the perception of a 'wind rush' in addition to excluding small-scale and community projects (typically more expensive than larger projects).
1993	Reform of the NFFO: Extended contracts from 8 to 15 years. Clarification of UK renewable energy policy. Contractors offered bidding price (not strike price as NFFO2). NFFO round 3: Included new sub-bands for biomass gasification and small-scale wind but excluded sewage gas for the first time. Inclusion of the 'levy out' clauses (Regional electricity companies not required to make up the shortfall between the pool and premium price) and 'grace period' (5 years to obtain planning permission after contract awarded).
1997	NFFO round 4. Also supported renewable heat. New anaerobic digestion band and support for energy crops and forestry waste.
1998	NFFO round 5.
Renewables Obligation (RO)	
2002	RO comes into force.
2003	UK Government declares intention to reform RO. Emissions trading to be the key environmental tool going forward.
2004	RO (Amendment Order) to allow small-scale generators to qualify for RO subsidy.
2005	Aspirational extension of RO from 2010/11 (10.4% target) to 2015/16 (15.4% target) .
2006	First consultation on the reform of the RO (technology banding). Grandfathering put forward as an option.
2007	Second consultation on the reform of the RO (technology banding).
2008	Announcement that RO to be extended from 2027 to 2037.

Table 8.11 (Continued)

Reformed Renewables Obligation (rRO)	
2009	Reform of the RO (rRO). Technology banding, headroom mechanism and grandfathering (from 2006) introduced.
2009	First banding review (offshore wind) announced.
2009	Consultation on renewable electricity financial incentives. Options included: introduction of a small-scale feed-in tariff (FIT) mechanism (<5MW); extending the rRO to 2037; whether or not to change the offshore wind band support level; a price stabilisation mechanism (for subsidy level and/or electricity price).
2010	OFGEM's 'Project Discovery' report published discussing various options for reforming the electricity sector (including: low carbon obligation; long term contracts; RO tender; capacity tenders).
2010	Electricity Market Reform' Consultation and 'Energy Market Assessment' reports.
2010	Introduction of the Levy Control Framework (LCF) in the 2010 Spending Review to cover the period 2011-15.
2011	Publication of the Energy White Paper 'Planning our electric future' (including 4 key proposals: long term contracts form difference feed in tariffs (CfD FIT); carbon floor price (CFP); emissions performance standard (EPS); capacity market (CM).
2012	Reformed RO banding review. Small-scale FIT banding review.
2013	Additional banding review of onshore wind power subsidy level
2013	Carbon floor price introduced 1 April (£16/tonne) rising to £30/tonne (2020) and £70/tonne (2030).
2014	Beginning of RO/CfD FIT transition period (generators have the option to choose to accredit under the rRO or CfD FIT).
2017	RO vintaged (closed to new generation) and subsidy level grandfathered from 2017.
Contracts for Difference FIT (CfD FIT)	
2014	CfD FITs proposed to come into operation. Start of administrative price setting period (2014-17).
2017	CfD FIT operates as the sole subsidy mechanism for large-scale RES-E generation. Start of technology specific auctions (2017-mid 2020s).
mid-2020s	Start of technology neutral auctions (mid to late-2020s).
late-2020s	Start of wholesale market and carbon price (late-2020s onwards).
2029	End duration of first CfD FIT contract for renewables commenced in 2014.

SOURCE: DECC (2009a, b; 2010a; 2011b, c, d, e; 2012a, b); Gross and Heptonstall (2010); HM Treasury (2011); HM Treasury and DECC (2010); Mitchell (1995); Mitchell and Connor (2004); Office of Gas and Electricity Markets [OFGEM] (2010); Wood and Dow (2010, 2011).

and the 2003 '*Our energy future – creating a low carbon economy*' and 2007 '*Meeting the energy challenge*' Energy White Papers (Department of Trade and Industry [DTI], 2003, 2006a, 2007a).

This *de facto* priority in energy policy and renewable electricity policy in particular was one of the key reasons underlying the under-performance of the NFFO mechanism: the emphasis on reducing the average price per kWh of each NFFO bidding round to signify success leading to unrealistic (too competitive) bids constraining actual deployment levels. This internal failure of the NFFO was never addressed.[326] Reliance on such a market-dominated approach also led to similar issues under the RO/rRO. This is summed up by Woodman and Mitchell (2011: 3914):

> "*... the strategic emphasis on competition in the support mechanisms has played a key role in limiting renewable deployment... the mechanism has changed significantly since it was introduced. However, these changes... still do not address important elements of risk.*"

It becomes clear that the failure of the UK Government to address the main internal failures of the RO up to now, primarily price/financial risk and the resultant impact this has on developer/investor confidence and thus deployment levels is driving the successive waves of change in renewable energy policy (see Section 8.5.1.3 on policy reforms). In other words, subsidies are being used to compensate for the investment risks caused by deficiencies in the mechanism and thus renewable energy policy itself. Critically, the reform of the RO in 2009 failed to address this internal failure due in part to the overwhelming focus on a least-cost market approach (Wood and Dow, 2011). This is significant given the level of investment required for the UK to successfully meet the 2020 renewable energy targets. Importantly, this is one of the key reasons (in conjunction with carbon trading, see below) that have driven the successive waves of

[326] There are other problems with the NFFO including poor mechanism design (see Chapter Three, Section 3.3 for a detailed examination of this and the non-reformed RO mechanism).

regulatory and policy adjustments to both the RO and the rRO.[327]

It can be argued, however, that there has been a change in direction in UK government energy policy towards the end of the 2000s (Rutledge, 2010). Both DECC's report '*Energy Security: A National Challenge in a Changing World*' and OFGEM's '*Project Discovery*' reports published in 2009 pointed clearly to the need to move away from a complete reliance on liberalisation/competition and the market-based approach adopted since 1989 in the UK:

> "*My conclusion is that the era of heavy reliance on companies, competition and liberalisation must be re-assessed. The time for market innocence is over. We must still rely on companies for exploration, delivery and supply, but the state must become more active – interventionist where necessary.*" (DECC, 2009: 1).

The reasoning behind this was the increasing awareness that the '*Policy Trilemma*', or how to square the competing objectives of reducing greenhouse gas emissions ('*low carbon*'); securing energy supply ('*secured supply*'); and obtaining the lowest possible energy bills for consumers ('*low prices*') was more difficult than previously assumed (if assumed at all) (DECC, 2009). If government intervention is desirable, the critical question is to what extent and to what degree is intervention actually possible? These are particularly relevant questions. Government and the regulator do not own any energy infrastructure assets, nor can they build and operate such infrastructure. In the UK this is primarily the domain of the '*Big Six*' energy companies: this is where decisions on whether or not to invest in energy infrastructure, type of infrastructure, when and where to construct such infrastructure and the price of energy exist (albeit with some limitations). This can also at least partly explain the focus on large-scale RES-E deployment in contrast to the meso-scale and the problems that have constrained the operation of the small-scale feed-in tariff since its implementation in 2010. At the same time, in a very real sense, privatised energy companies are not required to be 'concerned' about systemic issues such as renewable/low carbon and climate change targets or security of supply issues except where they are obligated to do so. In addition,

[327] It could also be argued that this was also at least in part the reason behind reforming the RO (Wood and Dow, 2011).

government intervention has typically focused on some form of subsidy support. In other words, it is unlikely that any change in priority will occur with regard to the prevailing energy market orthodoxy (Rutledge, 2010).

Returning to the change in direction, perhaps the clearest result of this shift in priority can be seen in both the title and context of the most recent 2011 Energy White Paper '*Planning our electric future: a White Paper for secure, affordable and low-carbon electricity'* (DECC, 2011c). The introduction of the Contracts for Difference Feed-in Tariff (CfD FIT) mechanism for large-scale RET deployment will result in government essentially deciding the price, type and quantity of renewable, nuclear and carbon capture and storage (CCS) deployment. In addition, the Capacity and the Emissions Performance mechanisms will provide support for unabated CCGT generation technologies. Although this will be looked at in more detail in section 8.5.1.3, in effect this will return some leverage to the government in terms of '*planning*' the UK's electricity landscape. However, this is likely to be short-term, given the proposals to move towards competitive auctioning as soon as government deems is possible (DECC, 2011c).

There is also the issue of carbon trading and the EU Emissions Trading Scheme (EU ETS).[328] As Table 8.10 points out, the 2003 Energy White Paper highlighted the importance of carbon trading as the centre of environmental policy, just one year after the implementation of the mechanism. Carbon trading remains the key environmental policy tool for dealing with the issue of climate change, thus undermining confidence in the renewable-specific RO. Indeed the core strategy supported by the government to overcome the market failures to successfully tackle climate change and ensure security

[328] Described as the cornerstone of the EU's policy to combat climate change and reduce industrial greenhouse gas (GHG) emissions, the EU ETS works on the '*cap and trade*' principle: a cap is set on the total amount of defined GHG emissions that can be emitted by certain installations (primarily factories and power stations). Over time, the cap is tightened in order to increasingly reduce such emissions over time. One particular feature of the EU ETS is that companies receive or buy emission allowances that can be traded amongst the participants of the scheme. Those companies that fail to surrender sufficient allowances to cover the emissions are penalised; any excess allowances can be retained or sold (Europa, 2012). In essence, the EU ETS puts a price on carbon with the intention being to incentivise GHG emission reductions and to make typically more expensive low carbon and renewable generation financially more attractive to investors.

of supply involves putting a price on carbon emissions through the EU ETS (HM Treasury, 2010). The EU ETS is also an example of creating new markets as a means to achieve GHG emission reductions at the least-cost. The argument is that such a market-based approach will be more cost-effective in comparison to directly subsidising low carbon technologies with the original aim of the scheme being to ultimately replace such mechanisms in the future once these technologies become mature and competitive with traditional generation plant (Freestone and Streck, 2009). However, the failure of carbon pricing alone to reduce emissions at the scale and pace required and incentivise the growth of renewables in conjunction with the internal and external failures of the mechanism itself have also driven the successive waves of regulatory and policy change to the RO and renewables in general in the UK.

There has also been the issue of technology preference or prioritisation. Except for a relatively short period in the late 1990s and early 2000s, when the 2002 PIU '*Energy Review*' and the 2003 White Energy Paper essentially stated that nuclear power was not needed, nuclear power has remained a priority for various UK Governments (DTI, 2002, 2003). Prior to this period, renewable energy was effectively and opportunistically bundled with nuclear power to the detriment of the former category of technologies (see below). The most recent change in government priority for nuclear power, however, was kick-started by the 2006 '*The Energy Challenge: Energy Review*' (DTI, 2006). This was followed by the 2007 White Energy Paper and the publication of a nuclear-only White Energy Paper in 2008 titled '*Meeting the Energy Challenge: A White Paper on Nuclear Power*' (Department for Business, Enterprise and Regulatory Reform [BERR], 2008a; DTI, 2007a). These documents effectively returned nuclear power back into the policy fold. However, it is the 2011 Energy White Paper that will potentially re-bundle nuclear and power together, into the proposed Contracts for Difference Feed-in Tariff (CfD FIT) along with carbon capture and storage as the third low carbon option (DECC, 2011c). Although the particular details of the CfD FIT mechanism have not yet been established, this is arguably of concern for renewable electricity deployment for a number of reasons: the vast majority of subsidy when renewables and nuclear power were bundled together under the NFFO went to nuclear power between 1990-1998; a focus on a new and, if successful, substantial nuclear power programme could also reduce the amount of available investment from renewable deployment in addition to the allocation of subsidy via the CfD FIT. This will be compounded by the absence of a post-2020 target as of yet (see below)

8.5.1.2 Targets

Whether at the EU, UK or sub-national level, particularly in the case of Scotland, targets for renewable energy and renewable electricity in particular have been a consistent feature in the UK. These targets have ranged from 3 per cent by 1998 (NFFO); 10 per cent by 2010 (RO); 15 per cent by 2015 (RO); and culminated in the most recent RES-E sectoral target of 30-35 per cent by 2020 (rRO) (Europa, 2009; Gross and Heptonstall, 2010; Mitchell, 1995). However, there are historically and currently a number of issues with regard to the way in which targets have been set. The manner of target setting under the NFFO, based on irregular bidding rounds (UK: 1990, 1991, 1995, 1997 and 1998; Scotland: 1994, 1997 and 1998) resulted in uncertainty with both developers and supply chain companies not knowing in advance what the capacity targets would actually be. In contrast, there has been more certainty and advance notice about the way in which targets have been set under the RO. Despite this, there have been a number of issues that have reduced investor confidence. Although the DTI set a target of 15.4 per cent RES-E generation by 2015/16, only the period up to 2010 was covered by the target set by the 2001 EU Renewables Directive. The 2015/16 target remained merely '*aspirational*'. Critically, once the target was met, it would remain at the 2015/16 level until 2026/27. A long-term review of the energy options and challenges facing the UK, the 2002 PIU Energy Review recommended that the target should be increased to 20 per cent by 2020. However, as set out in the 2003 Energy White Paper, this became another aspirational target. The preferred choice of aspirational over mandatory targets means that they do not have any impact on the application of policy instruments and investor/developer behaviour (Lauber, 2005).

The only real certainty arising after the target set by the RO back in 2000 was the proposal in the 2006 Energy Review to introduce a headroom mechanism. This would ensure that the level of the Obligation would always stay above the level of renewable generation. However, this was a curious proposal for one key reason: it would be capped up to the aspirational 20 per cent by 2020 target; critically, it was already clear that the UK RES-E target for 2020 was always going to exceed this level for a number of reasons including more demanding climate change targets, the need to decarbonise the electricity (power) sector first, the looming capacity gap and the increasing electrification of the heat and transport sectors in addition to EU climate and energy policy objectives (Wood, 2010). As such, although this was initially viewed as a positive step, this was arguably an unnecessary one that increased policy uncertainty. In the end, with the 2009 EU Renewables Directive and the setting of the sectoral RES-E target of 30-35 per cent by 2020 (a core component of the legally-binding target of 15 per cent of total energy from renewable energy sources by 2020), the 20 per cent aspirational cap was removed and headroom maintained in the 2009 reform of the RO.

In contrast, there has been a consistent and clear method in setting targets for renewable energy and RES-E in particular in Scotland. In contrast to the UK and the other devolved administrations, Scotland has led in setting new and higher targets and has so far been successful in meeting these targets:

> "*In Scotland the setting of ambitious national targets has been a key feature of a policy agenda spanning successive governments... The Scottish Government was the first among the devolved governments to set a new target, back in 2000, of meeting 17.5% of Scottish electricity consumption from renewable sources by 2010, and the next decade saw Scottish targets increased repeatedly. An important factor – and a distinctive facet of renewable energy policy dynamics within the UK – is that Scotland has actually managed to meet a succession of its own national targets set above the UK norm: targets to meet 31% of electricity demand from renewables by 2011... It seems that successful implementation in turn is driving higher targets and the Scottish Government has gone on to establish the goal of matching 100% of Scotland's electricity consumption from renewables by 2020.*" (Cowell et al., 2013: 15).

However, increasingly ambitious targets results in the governance and societal challenges of meeting these targets increasing, with regard to attempts to address the internal and external failures.

Currently there is no post-2020 renewables target at either a pan-EU or UK level. However, the European Commission (EC) recently published a Green Paper titled '*A*

2030 framework for climate and energy policies' (EC, 2013). Critically, the UK government has made clear its position that it is not in favour of any post-2020 renewables-specific targets. In particular, the Secretary of State for Energy and Climate Change [DECC], Edward Davey, has stated that

> "*... we need a technology neutral approach to how individual countries meet their emissions targets. We want to maintain flexibility for Member States in the exact energy mix they use… We will therefore oppose a renewable energy target at an EU level as inflexible and unnecessary.*" (DECC, 2013: 1).

The position put forward by the UK government is for a more ambitious greenhouse gas emissions target: a 50 per cent reduction by 2030 on 1990 levels (DECC, 2013). Although this does tie in with the proposed UK CfD FIT that aims to provide support for all low carbon technologies, there is no proposal for any technology target, whether renewables-specific or low carbon. Regarding the proposed 2030 renewables target, the UK approach fails to recognise the both the importance of the previous targets (2010, 2020) in driving renewable deployment and the limited impact of the EU ETS so far (see also section 8.5.1.1):

> "*... the only thing that is driving real clean investment in Europe is the renewables target. It is not being driven by the carbon price. I think it is really important to distinguish that. The real driver for investment is the renewables legislation, not the carbon price. There is an implicit carbon price within that legislation, but it is not set by the ETS.*" (Allot, 2010: 69).

It is the absence of a post-2020 mandatory target in particular that would introduce a significant policy risk to investor confidence. Opposing a future renewables target, particularly in light of the fact that there is no alternative target (such as a low carbon target, legally-binding or otherwise), would result in slowing down at best and halting renewable deployment levels at worst. This is highlighted in DECC's '*Updated Energy and Emissions Projections – October 2012*' modelling. This shows that renewable deployment under all scenarios (low/high prices, low/high growth and central scenario) will essentially stagnate post-2020 under analysis that assumes there is no future target (DECC, 2012c).[329] In addition, this was precisely the same situation that would have occurred under the RO prior to mechanism extension to 2037. As Figure 8.5 (page 423) shows, there was no anticipated RO-eligible generation after 2020/21 with an overall decrease in new generation from approximately 2015/16 onwards whilst the duration of the RO was set until 2026/27. This was a direct consequence of the finite duration of the RO impacting on investment decisions: there was no expectation of future ROC revenues after 2026/27 and the predicted remaining revenues from the sale of electricity were deemed insufficient by themselves to bring forward new deployment despite the subsequent upturn in ROC values for those technologies banded-up (Oxford Energy Research Associates [OXERA], 2007).

There are a number of additional reasons why it is recognised as necessary to already set in place post-2020 targets to avoid a policy void. In addition to a narrow focus on greenhouse gas emission reductions, investment in renewable energy can stimulate economic growth (both domestic and export) in new and fast-growing global markets; reduce greenhouse gas emissions and other particulate pollution; reduce dependency on finite sources of energy, volatile imports of energy (in terms of price and geopolitical issues) and the permanent storage of energy waste (nuclear and potentially CCS); help improve the balance of payments (for most renewable sources particularly if properly managed).[330]

8.5.1.3 Reviews and reforms

As shown in Table 8.11, a major defining characteristic of UK renewable electricity policy has been that of constant reviews, reforms and adjustments. Although overall beneficial to RES-E deployment (primarily by extending mechanism duration from eight

---

[329] At the EU-level, renewables deployment has been strongly correlated by target setting: renewable energy grew by 1.9 per cent per annum prior to any regulatory framework (1995-2000); by 4.5 per cent per annum following the introduction of indicative targets (2001-2010); and 5.6 per cent per annum with legally-binding targets to meet the 2020 target (2010-onwards). Despite this, growth still needs to increase to 6.3 per cent per annum if the target is to be achieved (EC, 2013). Of course, targets are not sufficient in isolation.

[330] A number of these reasons have been contiguously set out as UK energy policy objectives for over two decades (in particular, see chapter three).

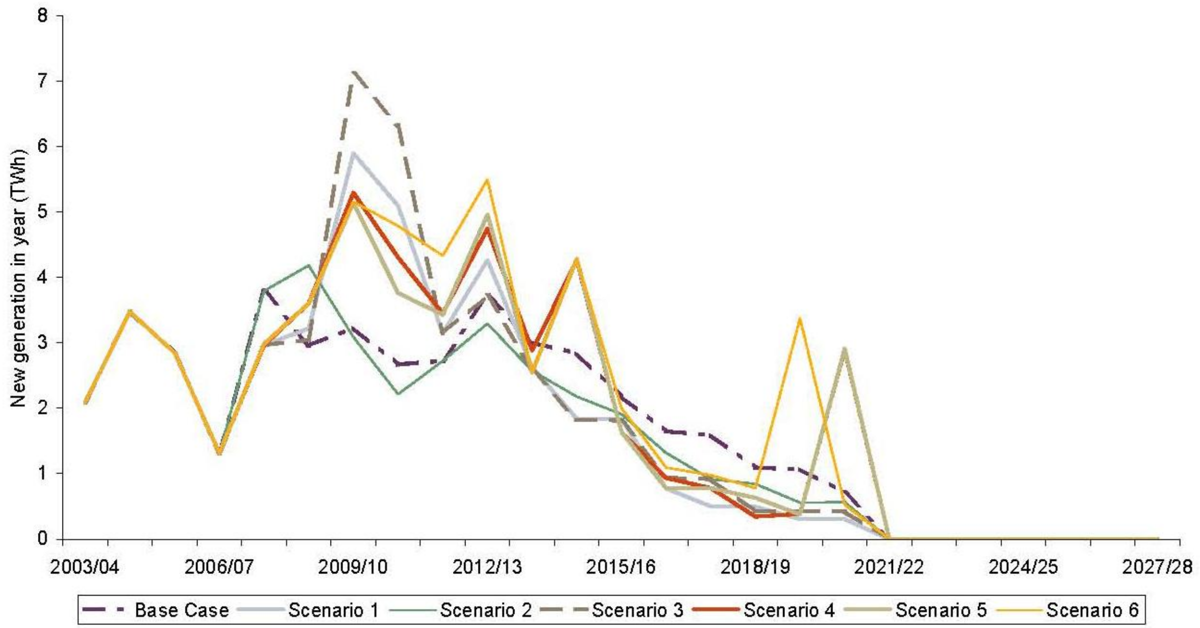


Figure 8.5 Anticipated year-on-year levels of new renewable generation 2003/04 to 20227/28 (OXERA, 2007: 36).

Note: The data utilised in this analysis is based on the RO mechanism ending in 2026/27. The base case represents the non-reformed RO and scenario 6 represents the reformed RO.

to fifteen years), the NFFO mechanism was reformed within three years of initial implementation. It did little, however, to address key barriers to deployment (excessive focus on competition and achieving the least-cost approach in combination with the absence of a penalty mechanism for non-construction and the failure to address planning issues). The end result was that only around a third of contracted generation actually reached commissioning and ultimately the NFFO was replaced with the RO but only after a four year hiatus (Wood and Dow, 2011). Such policy risk resulted in negligible RES-E deployment during this period.

Put in place in 2002, the 2003 Energy White Paper effectively questioned the effectiveness and purpose of the RO by setting up a review of the mechanism (for 2005/06) and setting carbon trading as the cornerstone of energy policy just one year after implementation of the new scheme (Mitchell and Connor, 2004). Throughout the duration of the RO, both unreformed and reformed, there have been successive '*waves*' of regulatory, legislative and policy reform. As discussed in chapter seven, section 7.2 the continuous policy changes to large-scale RES-E include three '*waves*' of change: the reform of the RO; the '*Renewable Electricity Financial Incentives*' consultation process; and the proposal to introduce the CfD FIT mechanism and other proposals under the EMR process. The reasoning behind the changes in the first two 'waves' was primarily that they aimed to fundamentally re-orientate the RO to become more like a feed-in tariff, albeit a system that will remain an RO mechanism but with the added complexity of feed-in tariff like '*bolt-ons*' as opposed to actually being a feed-in tariff.

The reform of the RO was a long and drawn out process. Following from the DTI 2006 '*The Energy Challenge: Energy Review*', itself originally proposed previously in the PIU 2002 '*The Energy Review*', the UK government published three consultations (2006, 2007 and 2008) and two responses (January 2008 and December 2008) before publishing the '*Renewables Obligation Order 2009*' setting out the legislation underlying the actual reform (BERR, 2006, 2008b, c, d; DTI, 2002, 2006b, 2007b).[331] Although the RO reform (including the second wave of reforms) is discussed elsewhere in this thesis,

[331] The reform of the RO is discussed elsewhere in this thesis: in particular, see chapter seven.

it is important to highlight that the major internal failures were not addressed: revenue uncertainty (price risk) remained and the 2026/27 end date was not extended at the same time as the introduction of technology banding (Wood and Dow, 2011). In addition, the technology banding introduced a further and significant policy risk: renewable technologies could be both ‘banded-up’ and ‘banded-down’. The recent experience of solar PV under the small-scale and the recent banding review of the RO (including the two consultations on the subsidy level for onshore wind in addition to other RETs) emphasises this risk for investors/developers (see chapter seven). The second wave of reforms centred on the 2009 ‘*Consultation on Renewable Electricity Financial Incentives*’ (DECC, 2009a). Essentially this was reforming the RO in the same year as the reform of the mechanism. In addition to a number of further adjustments to the RO[332], the reforms included a number of structural changes to the design of the RO mechanism. As discussed above, the RO was extended to 31 March 2037. The consultation also contained two further proposals that had the potential to profoundly alter the way the RO operated and undermine key objectives of the scheme to bring forward and support UK-based renewable generation: The Price Stabilisation Mechanism (PSM) and permitting RES-E generation from stations out-with the UK.

The idea behind the PSM was to stabilise revenue from electricity prices for renewable electricity generators, with the option to extend this to ROC price revenue (Wood, 2010). A properly designed and implemented PSM could bring extra security for RES-E generators with regard to addressing revenue uncertainty, arguably the main internal failure of the RO mechanism. This is somewhat similar to the proposed CfD FIT; although there would undoubtedly be difficulties in designing a PSM as with the FIT, such an approach, embedded within the existing RO would avoid the added cost and complexity of introducing a new mechanism at a time when deployment is required to increase towards the approaching 2020 target deadline. On the other hand it could add further complexity and administrative costs (both of which would impact to a greater extent on smaller generators) to a mechanism already made more complex and

[332] These adjustments included carrying out an emergency banding review for offshore wind, resulting in the temporary banding up of subsidy from 1.5 to 2 ROCS per MWh and limiting subsidy support to twenty years for new projects accredited on or after 26 June 2008.

administratively burdensome via the 2009 reform process, distort the electricity market (by effectively cutting generators off from the market and removing their ability to respond to market signals), reduce revenue and increase policy risk (by representing a fundamental mechanism design and operational change from a market-based mechanism towards a FIT system). There were also concerns over opening up the RO to RES-E generation out-with the UK. Although ultimately funded by the UK consumers, subsidy payments would no longer be focused on inward investment in UK jobs and infrastructure, with concomitant impacts on supply chain growth and domestic/export markets. In the end, although the government proposed a further round of consultations to examine these proposals in greater detail were planned for the next year both were dropped with the election of a new government in 2010 (DECC, 2009b). What was effectively a major example of a missed opportunity (the PSM) ended up being another example of policy risk introduced by the government, particularly alongside the proposal to open up the UK to RES-E generation from abroad.

It becomes clear, however, that the failure of UK Government to address the main internal failures of the RO up to now, primarily price/financial risk and the resultant impact this has on developers/ investors and thus deployment levels is driving the successive waves of change in renewable energy policy. In other words, subsidies are being used to compensate for the investment risks caused by deficiencies in the mechanism and thus renewable energy policy itself. This is a critical example of policy risk: despite all the reforms, the internal (and external) failures were not addressed. In itself this increased the risk of further policy change. This is also significant given the level of investment required for the UK to successfully meet the 2020 renewable energy targets – around £18–19 billion annually up to 2020 (OFGEM, 2010). What is important is that at this time the UK appeared to be attempting to introduce a feed-in tariff style system '*through the backdoor*', via the successive waves of reform and adjustment. This leads to the question over whether or not it would have been better to switch to a FIT mechanism overall than propose further reforms and introduce a FIT constrained by the capacity cap. By the end of 2009, under a stable feed-in tariff mechanism, Germany had over 25GW of wind installed in comparison to just over 4GW in the UK, and around 16% share of electricity in comparison to 6.6% in the UK. In addition, feed-in tariffs

have had more success in installing non-wind renewable technologies such as solar PV (Bundesministerium fur UMWlt and Naturschutzund Reaktorsicherheit, 2010).
With regard to stated policy objectives, the retention of high price/financial risk and increased uncertainty looks set to remain a substantial barrier to UK renewable industry sector growth (domestic and export) and resultant employment uptake. Much of renewable energy generating technologies will continue to be imported from other countries, notably Germany and Denmark. Therefore, there is a very real risk that UK renewable policy will continue to subsidise other countries manufacturing and supply chain development, despite the concept that a move to a low-carbon economy will not just be costly but a substantial opportunity for the UK economy.

The third wave of reforms can only be described as an overhaul of the current UK electricity system framework:

> "*These reforms will yield the biggest transformation of the market since privatisation, securing our future electricity supplies and heralding the shift toward a low-carbon economy.*" (DECC, 2011c).

Whether or not such an approach to the large-scale renewable electricity landscape might prove beneficial in the long-term, there are a number of reasons why it increases policy risk as an external failure at least for the short and medium-term: it represents a major change for investors and developers. The adoption of a new mechanism and indeed a novel variant of the more traditional FIT mechanism used elsewhere will increase uncertainty at precisely the same time as the 2020 target is approaching. As of the end of 2012, the key CfD FIT details are still largely unknown.

Regarding the RO, as early as 2010, the EMR process set an end date for the extant mechanism before publishing sufficient detail regarding how the proposed replacement mechanism would actually operate. Additionally, there are a number of critical time '*windows*' throughout this process where, according to government, RES-E deployment is not only expected to continue during this period but actually accelerate towards the 2020 sectoral target: (1) under the RO but prior to the proposed operation of the CfD FIT in 2014 (where details will for the most part be unknown); (2) the transition period

2014-17 during which the RO and the CfD FIT will operate simultaneously (the bedding in period for the new mechanism which could lead to uncertainty over which mechanism to chose). This is further compounded by the fact that the EMR process, as with the NFFO/RO transition and the 2009 RO reform, has also been a long and rather convoluted (difficult) process (commencing arguably in 2009 with the publication of OFGEM's '*Project Discovery*' document). Importantly, the process is still on-going and the CfD FIT delivery timetable has been and continuous to be very demanding (DECC, 2011e).

It is very difficult to understand how investors/developers can make an informed and timely choice given the above reasons.[333] This could lead to a hiatus in renewable deployment at a critical stage as occurred at the previous NFFO/RO hiatus.[334] It could also lead to increased investment and deployment in non-renewable technologies, and gas and shale gas in particular. In turn, this has particular implications for the development of a domestic supply chain in addition to the set targets. Further, from a systemic evaluation perspective, the CfD FIT only focuses on addressing the internal failures, in particular the price (revenue) risk and it is unclear if the remaining internal failures will be addressed: in its current manifestation, the CfD FIT is already as complex if not more so than the RO; there is no certainty on how long the mechanism will run or how it will change (only that the ambition is to move to technology-neutral auctions in the 2020s); and volume risk, particularly as there is no Obligation on suppliers to purchase RES-E generation and given that there is currently no post-2020 target, see above. As mentioned previously, there is also uncertainty regarding the bundling of renewables with nuclear and CCS. Critically, the new mechanism fails to address the external failures at all. This is in contrast to the traditional FIT mechanism adopted abroad (see above).

[333] The EMR process itself very strongly indicates that the previous approach and all the constant reforms and adjustments was not effective in delivering the required level of RES-E deployment. It can be argued that this alone introduces uncertainty for investors/developers with regard to the EMR reforms, notably the CfD FIT.

[334] It is unlikely that the RO/CfD FIT transition will be as bad as the previous NFFO/RO transition which lasted for four years and saw virtually no deployment during this period (see chapter three).

However, the problem of such a plethora of policy change, both those enacted or merely proposed, bring a whole host of new problems and one growing area of concern that is possibly not being acknowledged properly is the impact that this will have on the renewables sector. Inevitably the point will come when the increased changes to the mechanism will out-weigh the benefits of any improvements – possibly this point has already been reached with regard to the impact on the renewables industry sector (although it should be noted that the RO favours large-scale companies and as such they will seek to maintain the status quo). What is apparent, though, is that the sheer number of changes mentioned here has the additional effect to increase policy uncertainty as an external failure. Indeed, it has the potential to become of critical importance in the near future.

References

Agnolucci, P. 2008. *Factors influencing the likelihood of regulatory changes in renewable electricity prices*. Renewable and Sustainable Energy Reviews (12): 131-161.

Allott, K. 2010. Witness Evidence Testimony to the House of Commons Environmental Audit Committee Report: The role of carbon markets in preventing dangerous climate change: Fourth Report of Session 2009-10 – 8 February 2010 [online] Available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/290/290.pdf

Bundesministerium für UMWlt, Naturschutz und Reaktorsicherheit, 2010. Entwicklung der erneuerbaren Energie in Deutschland im Jahr 2009 [online] Available from /http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/ee_hintergrund_2009_bf.pdfS

Committee on Climate Change [CCC], 2011. The Renewable Energy Review – May 2011 [online] Available from http://hmccc.s3.amazonaws.com/Renewables%20Review/The%20renewable%20energy%20review_Printout.pdf

Cowell, R., Ellis, G., Sherry-Brennan, F., Strachan, P. and Toke, D. 2013. Promoting Renewable Energy in the UK: What Difference has Devolution Made – Initial Findings, 23rd January 2013 [online] Available from http://cplan.subsite.cf.ac.uk/cplan/sites/default/files/DREUD-FullReport.pdf

Department for Business, Enterprise and Regulatory Reform [BERR], 2008a. Meeting the Energy Challenge: A White Paper on Nuclear Power – January 2008 [online] Available from http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file43006.pdf

Department for Business, Enterprise and Regulatory Reform [BERR], 2008b. Renewables Obligation Consultation: Government Response – January 2008 [online] Available from http://webarchive.nationalarchives.gov.uk/20090203212240/http://www.berr.gov.uk/files/file43545.pdf

Department for Business, Enterprise and Regulatory Reform [BERR], 2008c. Reform of the Renewables Obligation: Statutory Consultation on the Renewables Obligation Order 2009 – June 2008 [online] Available from http://webarchive.nationalarchives.gov.uk/20090203212240/http://www.berr.gov.uk/files/file46838.pdf

Department for Business, Enterprise and Regulatory Reform [BERR], 2008d. Reform of the Renewables Obligation: Government Response to the Statutory Consultation on the Renewables Obligation Order 2009 – December 2008 [online] Available from http://webarchive.nationalarchives.gov.uk/20090203212240/http://www.berr.gov.uk/files/file49342.pdf

Department of Energy and Climate Change [DECC], 2009a. Consultation on Renewable Electricity Financial Incentives 2009 [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20090722165845_e_@@_ConsultationonRenewableElectricityFinancialIncentives2009.pdf

Department of Energy and Climate Change [DECC], 2009b. Government Response to the 2009 Consultation on the Renewables Obligation [online] Available from http://www.decc.gov.uk/assets/decc/Consultations/Renewable%20Electricity%20Financial%20Incentives/1_20091214132326_e_@@_GovernmentResponse2009ConsultationontheRenewablesObligation.pdf

Department of Energy and Climate Change [DECC], 2009c. Energy Security: A National Challenge in a Changing World – August 2009 [online] Available from http://www.decc/gov.uk/en/content/cms/news/pn090/pn090.aspx

Department of Energy and Climate Change [DECC], 2010a. Electricity Market Reform: Consultation Document – December 2010 [online] Available from http://www.decc.gov.uk/assets/decc/consultations/emr/1041-electricity-market-reform-condoc.pdf

Department of Energy and Climate Change [DECC], 2011a. UK Renewable Energy Roadmap – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx

Department of Energy and Climate Change [DECC], 2011b. Consultation on proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: URN 11D/876: October 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Department of Energy and Climate Change [DECC], 2011c. Planning our electric future: a White Paper for secure, affordable and low-carbon electricity – July 2011 [online] Available from http://www.decc.gov.uk/en/content/cms/legislation/white_papers/emr_wp_2011/emr_wp_2011.aspx

Department of Energy and Climate Change [DECC], 2011d. Annexes to the White Paper: Annex D – Renewables Obligation transition [online] Available from http://www.decc.gov.uk/assets/decc/11/policy-legislation/EMR/2173-planning-electric-future-white-paper.pdf

Department of Energy and Climate Change [DECC], 2011e. Annex B: Feed-in Tariff with Contracts for Difference: Draft Operational Framework [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48373/5358-annex-b-feedin-tariff-with-contracts-for-differe.pdf

Department of Energy and Climate Change [DECC], 2012a. Government response to the consultation on the proposals for the level of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012: July 2012 [online] Available from http://www.decc.gov.uk/en/content/cms/consultations/cons_ro_review/cons_ro_review.aspx

Department of Energy and Climate Change [DECC], 2012b. Feed-in Tariff with Contracts for Difference: Operational Framework - November 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66554/7077-electricity-market-reform-annex-a.pdf

Department of Energy and Climate Change [DECC], 2012c. Updated Energy and Emissions Projections 2012 – October 2012 [online] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65717/6660-updated-emissions-projections-october-2012.pdf

Department of Energy and Climate Change [DECC], 2013. BLOG: Europe must stay ambitious on climate change by Edward Davey – May 28 2013 [online] Available from http://blog.decc.gov.uk/2013/05/28/europe-must-stay-ambitious-on-climate-change/

Department of Trade and Industry [DTI], 2003. Energy White Paper: Our Energy Paper – Creating a Low carbon Economy February 2003 [online] Available from http://www.berr.gov.uk/files/file10719.pdf

Department of Trade and Industry [DTI], 2006a. The Energy Challenge Energy Review Report July 2006 [online] Available from http://www.berr.gov.uk/files/file31890.pdf.

Department of Trade and Industry [DTI], 2006b. Renewable Energy: Reform of the Renewables Obligation and Statutory Consultation on the Renewables Obligation Order 2007: An Energy Review Consultation – October 2007 [online] Available from http://webarchive.nationalarchives.gov.uk/20090203212240/http://www.berr.gov.uk/files/file34470.pdf

Department of Trade and Industry [DTI], 2007a. Meeting the Energy Challenge: A White Paper on Energy May 2007 [online] Available from http://www.berr.gov.uk/files/file39564.pdf.

Department of Trade and Industry [DTI], 2007b. Renewable Energy: Reform of the Renewables Obligation – May 2007 [online] Available from http://webarchive.nationalarchives.gov.uk/20090203212240/http://www.berr.gov.uk/files/file39497.pdf

Europa, 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources [online] Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Europa, 2012. The EU Emissions Trading System (EU ETS) [online] Available from http://ec.europa.eu/clima/policies/ets/index_en.htm

European Commission, 2013. Green Paper: A 2030 framework for climate and energy policies – COM(2013) 169 final – 27.3.2013 [online] Available from http://ec.europa.eu/energy/consultations/doc/com_2013_0169_green_paper_2030_en.pdf

Freestone, D. and Streck, C. 2009. Legal Aspects of Carbon Trading: Kyoto, Copenhagen and beyond (eds). Oxford University Press: Oxford.

Gross, R. and Heptonstall, P. 2011. Time to stop experimenting with UK renewable energy policy: ICEPT Working Paper – October 2010: Ref: ICEPT/WP/2010/003 [online] Available from https://workspace.imperial.ac.uk/icept/Public/Time%20to%20stop%20experimenting.pdf

Helm, 2006. From Review to Reality: The search for a credible energy policy – A report for the Social Market Foundation [online] Available from http://www.smf.co.uk/files/2013/2317/4525/ReviewtoReality_credibleenergypolicy.pdf

Helm, D. 2008. Energy, the State, and the Market: British Energy Policy since 1979 – Revised Edition. Oxford University Press: Oxford

HM Treasury, 2010. Budget 2010 — Securing the Recovery: Economic and Fiscal Strategy Report and Financial Statement and Budget Report — March 2010 [online] Available from: /http://www.direct.gov.uk/en/Nl1/Newsroom/Budget/Budget2010/DG_188139

HM Treasury, 2011. Control framework for DECC levy-funded spending – March 2011 [online] Available from http://hm-treasury.gov.uk/d/control_framework_decc250311.pdf

HM Treasury and DECC, 2010. Energy Market Assessment – March 2010 [online] Available from http://www.decc.gov.uk/assets/decc/1_20100324143202_e_@@_budget2010energymarket.pdf

House of Lord's Select Committee on Economic Affairs, 2008. The Economics of Renewable Energy - Volume I: Report – 4th report of Session 2007-08 [online] Available from http://www.publications.parliament.uk/pa/ld200708/ldselect/ldeconaf/195/195i.pdf

Lauber, V. 2005. Switching to Renewable Power: A Framework for the 21st Century (ed). Earthscan.

Mitchell, 1995. The renewables NFFO – A review. *Energy Policy* 23(12): 1077-1091.

Mitchell, C. and Connor, P. 2004. Renewable energy policy in the UK 1990-2003. Energy Policy: 32: 1935-1947

Mitchell, C. 2008. The Political Economy of Sustainable Energy. Palgrave Macmillan.

Office of Gas and Electricity Markets [OFGEM], 2010. Project Discovery: Options for delivering secure and sustainable energy supplies – Consultation: Ref: 16/10: 3 February 2010 [online] Available from http://www.ebso.org.tr/b2b/ebsodergi/resimler/OFGEM_Project_Discovery_FebConDoc_FINAL.pdf

Oxford Energy Research Associates [OXERA], 2007. Reform of the Renewables Obligation: What is the Likely Impact of the Changes? [online] .Available from http://www.berr.gov.uk/files/file39039.pdfS

Pearson, P. and Watson, J. 2012. UK Energy Policy 1980-2010: A history and lessons to be learnt – A review to mark 30 years of the Parliamentary Group for Energy Studies [online] Available from http://sro.sussex.ac.uk/38852/1/uk-energy-policy.pdf

Rutledge, I. 2010. UK energy policy and market fundamentalism: A historical overview. In: I. Rutledge and Wright, P. (eds) UK Energy Policy and the End of Market Fundamentalism. Oxford University Press: Oxford.

Rutledge, I. and Wright, P. 2010. UK Energy Policy and the End of Market Fundamentalism. Oxford University Press: Oxford.

Scottish Government, 2011a. Renewables revolution aims for 100% [online] Available from http://www.scotland.gov.uk/News/Releases/2011/05/18093247

Scottish Government, 2011b. 2020 Routemap for Renewable Energy in Scotland [online] Available from http://www.scotland.gov.uk/Resource/Doc/917/0118802.pdf

Wood, G. 2010. Renewable energy policy in Scotland: An analysis of the impact of internal and external failures on renewable energy deployment targets to 2020 – CEPMLP Energy Series. University of Dundee: Dundee.

Wood, G. and Dow, S. 2011. *What lessons have been learned in reforming the Renewables Obligation? An analysis of internal and external failures in UK renewable energy policy*. Energy Policy 39(2011): 2228-2244.

Woodman, B. and Mitchell, C. 2011. Learning from experience? The development of the Renewables Obligation in England and Wales 2002-2010. Energy Policy 39(2011): 3914-1921.

Chapter Nine
Evaluating Potential Constraints to Renewable Electricity Deployment: A Systemic Approach Perspective

9.1 Introduction

The purpose of this chapter is to utilise the analysis of both the internal and external failures presented in chapters 6 and 7, respectively, to reveal the systemic interactions of the potential constraints examined here. This will be done in order to evaluate the current UK approach to addressing the potential constraints to large-scale RES-E deployment from a systemic perspective. This chapter, then, will seek to look at the system as a whole.

This chapter will be set out as follows: Section 8.2 will carry out an evaluation of the internal and external failures from a systemic approach perspective. Although this section will look at the internal and external failures in a particular order, it is important to emphasise that there is no single way to look at this: the potential constraints could be set out in any order or starting point, for example, starting with planning, or price/revenue risk.

9.2 An evaluation of internal and external failures from a systemic approach perspective

The key systemic interactions of the internal and external failures examined in this thesis are portrayed in Figure 9.1 (page 438). The use of a flow chart permits the documentation of the complex and inter-linked system and shows how the steps in the process work and fit together from a systemic approach perspective by mapping out the interactions between the potential constraints. It is clear from Figure 9.1 that the interactions cascade down through the flow chart; however, there are also a number of feedbacks within and between the internal and external failure categories (see below).

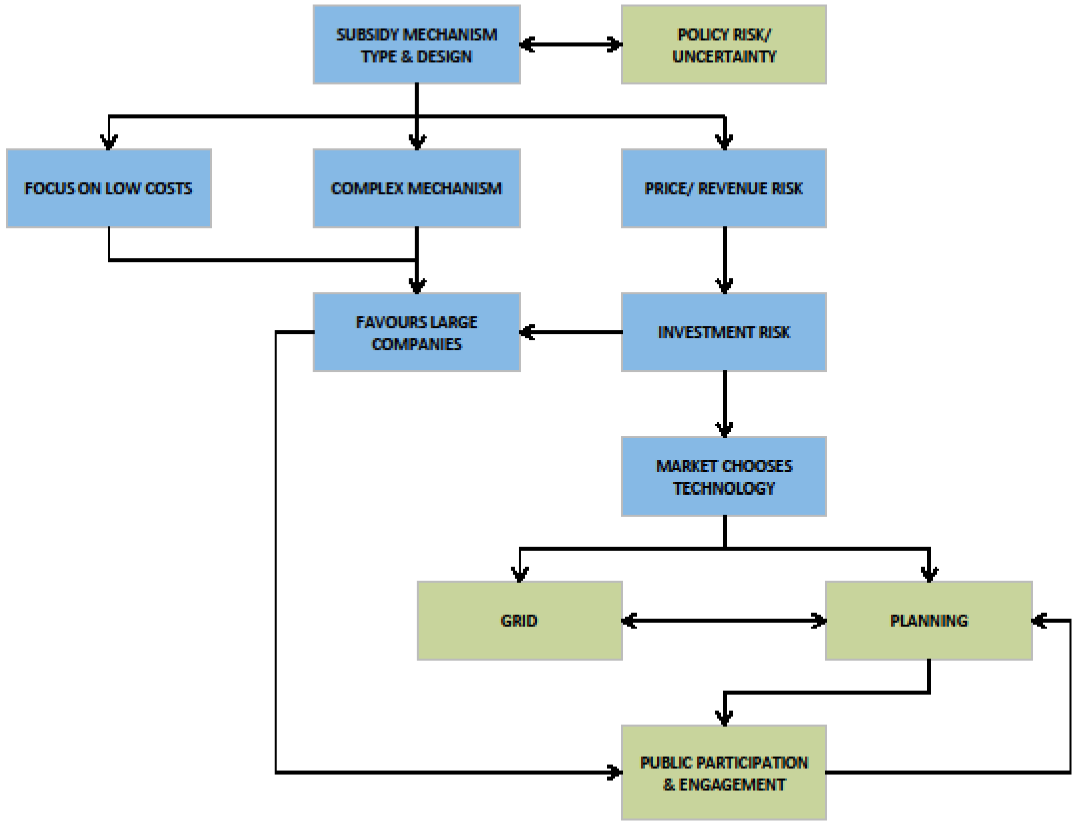


Figure 9.1 Flow chart of the systemic interactions of the key internal and external failures

Note: Blue boxes = Internal failures, green boxes = external failures

There are six internal failures that can be attributed to the type and design of the Renewables Obligation subsidy mechanism implemented by the government: ***Focus on Low Costs***, ***Complex Mechanism***, ***Price/Revenue Risk***, ***Favours Large Companies***, ***Investment Risk*** and ***Market Chooses Technology***. The emphasis on ***Focus on Low Costs*** was aimed at forcing renewable electricity technologies to become increasingly cost-competitive with non-renewable technologies over time. The least-cost market ready RETs would be deployed first, with more expensive technology options (near market, further from market) assumed to be sequentially picked up by the market as costs declined. Higher levels of subsidy would be offered to bring forward non-market ready RETs, particularly where there is the potential for large-scale deployment. However, recent changes to the support offered by technology banding, largely driven by the Levy Control Framework (a Treasury-led initiative with the aim of constraining the costs of financially supporting RES-E deployment) has resulted in subsidy cuts over the remaining duration of the subsidy mechanism for the majority of the technology bands irrespective of the scale of the development; this includes both those RETs designated as key to meeting the RES-E sectoral target (including onshore wind, offshore wind and biomass conversion; the exception here is dedicated biomass that has had subsidy levels increased, albeit under capacity constraints) and technologies near or far from market ready (including solar photovoltaic, geothermal).

This leads to two main consequences. It discriminates in favour of larger-scale developments that can gain from economies of scale. Further, by not taking into account the temporal dimension, the RO '*picks*' cheaper technologies to the exclusion of more expensive, less market-ready options that could also bring additional systemic benefits including technologies that are less contentious to the planning system (see below) and/or could be located closer to existing grid infrastructure with or without sufficient capacity.[335] There is also the issue of scale and the type of development/ownership model, again with systemic implications for planning and public participation and engagement.

[335] There are additional benefits including providing base-load output and flexibility of generation.

This bias will be exacerbated as the cuts increase over the remaining duration of the mechanism. Additionally, if expected cost reductions are not achieved to the extent anticipated by government, this will have a detrimental affect. This is particularly the case for the deployment of offshore wind, a key technology for achieving the 2020 RES-E sectoral target, as subsidy levels decline out to 2016/17. There is also the issue of linking a number of other RETs to the level of subsidy (and the planned subsidy cuts between 2014/17) offered to offshore wind, despite the differences between the different technologies. In terms of the systemic interactions of the potential constraints, therefore, the ***Focus on Low Costs*** exacerbates the mechanism to ***Favours Large Companies*** (see below). In addition, this level of fiscal constraint has led to domestic manufacturers and supply chain companies being unable to meet equipment/service demands.[336] This has resulted in developers sourcing equipment and expertise from abroad, thus aggravating extant problems of the development and growth of a domestic renewable industry and supply chain sector with concomitant impacts for employment and export capabilities.

The RO is also a ***Complex Mechanism*** in terms of design, administration and the level of knowledge and expertise required to operate within the mechanism. The introduction of technology banding has increased mechanism complexity, in addition to the constant reforms and adjustments to the mechanism design. This is particularly the case surrounding the rules regarding the various biomass technology options (for example, sustainability and fuel content rules). There are a number of reasons why the complexity of the RO can be said to exacerbate the internal failure ***Favours Large Companies*** (see below). A ***Complex Mechanism*** adds uncertainty from the perspective of all potential investors. However, large companies are better able than smaller generators to manage this complexity with in-house expertise and/or the ability to pay for such expertise. Mechanism complexity itself could act as a barrier to new entrants, particularly at the small, independent and/or community level. There is also the issue of lobbying and rent-seeking due to mechanism complexity, with numerous groups (for

[336] Although this occurred under the small-scale FIT subsidy mechanism, the damage and subsequent loss of jobs/companies within the sub-5MW solar photovoltaic supply chain sector (and loss of deployment) is revealing.

example, trade bodies, environmental organisations and within government) arguing for and against specific RET options against the back-drop of subsidy levels in particular.

The third internal failure directly attributed to the type and design of the RO is that of ***Price/Revenue Risk***. Renewable electricity generators face uncertainty with regard to the value of the key revenue streams: ROCs, electricity and the buy-out premium. Such uncertainty, by increasing the cost of finance through the addition of a risk premium on capital, gives rise to ***Investment Risk*** as another internal failure. In addition, ***Price/Revenue Risk*** and ***Investment Risk*** both effectively ***Favours Large Companies***: Large companies, typically vertically re-integrated former monopoly utilities can mitigate the risks through their ability to obtain cheaper finance due to their balance sheets or by managing the risks in selling both ROCs and electricity through trading between the generation and supply assets. Such in-house trading is effectively impossible for independent and smaller/community based developments. This also reduces liquidity in the ROC market with a further concomitant impact on non-vertically reintegrated companies. ***Favours Large Companies*** also affects the external failure ***Public Participation and Engagement*** (see below).

An inherent feature of the RO is that the government sets the target or obligation whilst the market '*chooses*' the technology and the price. From the discussion above, it is clear that the internal failure ***Market Chooses Technology*** essentially reinforces the other internal failures (Figure 9.1). The market up-takes the cheapest technology options first. Although this approach has been recently tempered with the introduction in 2009 of differential subsidy support levels for different technologies (or groupings of technologies), the outcome of this relatively new approach has been to retain the focus on concentrating deployment on a few select technologies. In other words, the RO has maintained support for onshore wind and increased support in particular for offshore wind, biomass conversion, dedicated biomass and co-firing. Banding also does not reflect the different sizes of developments. In addition, banding also emphasises the shift towards '*picking winners*' by the government, albeit a move constrained by the emphasis on low cost.

This exacerbates both ***Planning*** and ***Grid*** as external failures. Regarding ***Planning***, a significant amount of the RET deployment required to meet the sectoral target still needs to apply for planning consent. The overwhelming bulk of deployment in terms of installed capacity will come from onshore wind, offshore wind and, to a substantially lesser extent, the key biomass electricity technologies (see above). The RET options incentivised by the RO mechanism design are, however, particularly contentious to the planning system due to their technology-specific attributes. These include particulate pollution and sustainability issues for biomass. This is especially relevant for large-scale biomass conversion plant (in terms of installed capacity). Anticipated to account for the majority of new biomass capacity, such plant will require significant volumes of biomass fuels, with the overwhelming bulk coming from abroad. For wind power, the key attributes of relevance here are the very high geographical dispersal rate, very large plant size, relatively small generation output and the landscape '*footprint*' of the technology itself.

This is especially acute for onshore wind due to the high existing level of deployment (operational and under-construction) and the amount of capacity awaiting planning determination (and awaiting construction). This is further complicated for onshore wind by the reduction over time in the average size of projects (in MW), necessitating the need for more projects to enter the planning system. This can only increase the siting of onshore wind farms, proposed or actual, in novel locations that typically experienced limited if any such '*industrial*' deployment previously. The same is true for offshore wind, with the exception that there is a substantially higher amount of capacity either awaiting determination or at some stage in the development pipeline. As this occurs, this will increase pressure on the planning system. Further, this is exacerbated by the need for wind developers to maximise revenue by opting to locate in the areas of highest resource which are typically in areas of contention.

Recent legislative changes to the planning system in both England and Scotland have resulted in a concentration in control by central government. This has been particularly pronounced for the offshore planning system in both countries and across the UK in general. This has led to a top-down imposition of generation infrastructure on local areas and local communities. This can be seen by the fact that approval rates for >50MW projects for at least for the last six years has on average remained at around 90 per cent for the four RETs anticipated to contribute the majority of total installed capacity by 2020. Although offshore wind and biomass conversion projects are invariably large-scale projects, this figure is in stark contrast to the approval rate for sub-50MW onshore wind developments that fall under local planning authority jurisdiction over the same period. The increasing centralisation of power and decision-making has resulted in the erosion of public participation and engagement in the planning system. In addition, the planning system does not take into account local/community-scale development or alternative development models of ownership. These are the key underlying reasons why ***Planning*** exacerbates the external failure ***Public Participation and Engagement***.

The systemic interaction between ***Planning*** and ***Public Participation and Engagement*** also involves a strong feed-back element as shown in Figure 8.1. Critically, there is no real involvement of the public in the actual planning decision-making process, in terms of the design and through some form of ownership of a project. Instead, the role of the public is typically channelled by a sequence of consultations, including the pre-application consultation. Indeed, the current approach is rather to incentivise local people to accept developments through financial community benefits which are both divisive and further seek to limit the role of public participation and engagement in the process. Additionally, the system is dominated by large-scale, typically ex-utility multi-national companies. This affect is shown by the arrow leading from ***Favours Large Companies*** to ***Public Participation and Engagement***. In addition, the absence of so-called '*no-go*' areas for deployment has also increased the perception that developments could occur anywhere. Increasingly relevant to onshore wind deployment, this adds to public frustration with the planning system particularly when local communities find themselves in the position of repeatedly opposing developments in the same location despite previous such applications being refused planning consent. These are important issues for two key reasons. Importantly, the planning system is the primary way in which the majority of the public '*interfaces*' with renewable energy deployment. Secondly, there are significantly more sub-50MW renewable projects coming into the planning process in terms of number of projects and installed capacity than >50MW projects; as such they fall within local planning authority jurisdiction where people have more representation.

The same attributes for both onshore and offshore wind power also affect ***Grid***. Both RETs necessitate significant upgrade and extension of the UK electricity network in order to increase network capacity and extend the network to be able to incorporate new onshore and offshore wind, in addition to non-wind (and non-renewable) capacity requiring such connection. For onshore wind, this includes the transmission and distribution network; offshore wind has required the construction of an entirely new offshore transmission system, with associated onshore links. This has led to a number of issues for deployment that also reveals the systemic interaction between ***Planning*** and ***Grid***. Additional pressure on the planning system - growth in grid infrastructure/capacity requires planning consent at an unparalleled number of (often novel) locations across the UK. The growth in grid infrastructure falls disproportionately within Scotland. As of 2011, Scotland accounts for 64 per cent of total UK onshore wind installed capacity; onshore wind also accounts for 63 per cent of total RET installed capacity in Scotland. According to the UK Renewable Energy Planning Database, this trend will become more exaggerated over time. With an already heavily congested grid network, this is the reason why two-thirds of the anticipated spend on new onshore grid is allocated within Scotland alone.

Further, there is also a need to match onshore grid and generation infrastructure and offshore grid and generation infrastructure to onshore grid and generation infrastructure developments in a timely fashion. This has proved difficult, particularly for onshore deployment. This can be seen by the recent adoption of both the Connect and Manage approach (to incentivise generation infrastructure) and the RIIO approach (to incentivise transmission infrastructure); although roughly complementary with regard to overall aims, neither approach is particularly joined-up with the danger of stranded assets. Given that the growth in onshore grid infrastructure is being primarily driven by new renewables (in particular, onshore wind), there is also the question of whether justification for the need for so much onshore work is required if the substantial amount of offshore renewable deployment (offshore wind and marine RETs) occurs. This is also relevant given that the highest levels of grid constraint currently occur in Scotland and at the Scottish/English interface, and that the bulk of onshore wind deployment (actual and proposed) is located in Scotland.

As pointed out previously, the interactions cascade down through the flow chart shown on Figure 9.1. In other words, all the internal and external failures drive ***Policy Risk*** to varying extent, and affect policy risk as an external failure that, in turn, impacts on the system as a whole.

Part IV

Conclusions

Chapter Ten
Conclusions

10.1 Introduction

This thesis has carried out an evaluation of the current UK approach to large-scale renewable electricity technology deployment to 2020 and beyond by adopting a systemic framework approach to determine whether or not the UK will be successful in addressing the potential constraints – the internal and external failures – to deployment.

As derived from the considerations above, three specific research questions were posed. Each will be answered below.

10.2 Answering the research questions

(1) What are the implications of the current UK approach to addressing potential constraints to RES-E deployment to 2020 and beyond?

At present, the deployment of renewable electricity technology is dependent on an acceptance of policy risk and uncertainty. As the scope, ambition and challenges facing deployment has increased, changes in policy are both required and necessary. However, a key implication of the current UK approach to deployment, namely by not taking into account the systemic interactions of the internal and external failures in attempting to address the potential constraints, is that it forces every decision to be made on a separate case-by-case basis, with the result that more changes to the system leads to less clarity of where the risks will fall.

This is not to say that the reforms and adjustments have had no impact on deployment (see below). However, despite almost continuous reform over two decades and three mechanisms (NFFO, RO and rRO), there has been no fundamental change regarding the overall UK approach. Government attempts to increase deployment in order to achieve the RES-E sectoral target remains largely based on ad-hoc decisions. As such, the reforms have had a narrow focus; their application has been to address individual constraints (either internal or external failures) or a specific problem and not from a holistic perspective. The reform of the Renewables Obligation in 2009 and onwards has provided a '*renewables package*' by comprehensively addressing both internal and external failures, but this was based on the realisation by government that the failures required addressing more or less at the same time, and not systemically. Importantly, this is also despite the fact that this is a heavily regulated sector and will continue to be so at least into the 2020s as the RO mechanism is replaced by the proposed Contracts for Difference Feed-in Tariff.

Another implication of the current UK approach is that it is closely linked to the idea of the primacy of market solutions to addressing the potential constraints to renewable deployment. It is based on a *de-facto* dominance of economics, with deployment incentivised through a focus on least-cost and competition; the Renewables Obligation is driven by the relationship between regulatory return and the cost base, in light of the market price. In contrast, this has resulted in a system that has permitted little focus on social and behavioural issues, in particular the opportunity for participation and engagement in both ownership, decision-making and understanding for a variety of smaller-scale participants..

The consequences of the current UK approach, then is that it strongly discriminates in favour of the following system characteristics:

(i) A particular scale of development: predominantly large-scale; this is particularly relevant for onshore deployment. In 2011, only 25 per cent of onshore wind developments were '*small-scale*', categorised as having an installed capacity of 25MW or less; approximately 3 per cent of offshore wind projects are of a similar scale.

(ii) A select few renewable technologies irrespective of the technology-specific attributes: onshore wind, offshore wind, biomass conversion and dedicated biomass.

(iii) An even fewer number of RETs that are anticipated to provide the majority of deployment capacity with regard to the 2020 sectoral target: In 2011, the key RETs accounted for approximately 70 per cent of installed capacity (onshore wind: 37 per cent; offshore wind: 15 per cent; biomass conversion: 16 per cent). By 2020, the overwhelming majority of deployment capacity is anticipated to come from onshore wind and offshore wind alone.

(iv) A limited number of developers of a particular type: former utility, multi-national energy companies; the '*Big Six*' companies alone own around 50 per cent of renewable generating capacity. The remainder of the capacity is owned by other ex-utilities and, to a lesser extent, independents, with less than 1 per cent owned and operated (on a partial or full share basis) by small-scale non-commercial developers, organisations and individuals.

As can be seen from the analysis of the internal and external failures carried out from both a historical (Non-Fossil Fuel Obligation and the Renewables Obligation: see chapter three) and a contemporary (reformed Renewables Obligation: see chapters seven and eight) perspective, the current UK Government approach has exacerbated the systemic interactions of the internal and external failures evaluated in this thesis (see section 9.2). In order to achieve the 2020 RES-E target and the longer-term electricity sector decarbonisation requirements post-2020, renewable electricity technology deployment in the UK will have to increase substantially. RET deployment has increased, particular with the introduction of the Renewables Obligation mechanism in 2002 and due to the reform of the mechanism (although the reform benefitted offshore wind in particular) Given historical annual capacity growth to date, the trend in new installed capacity of the key technologies will have to follow the pattern of year-on-year accelerated deployment.

Indeed, this accelerated progress in new capacity additions to existing deployment levels is required under the modelling scenarios for the 2020 RES-E target to be achieved. However, this does not take into account the systemic interactions of the internal and external failures, particularly for those technologies anticipated to contribute the most. The required level of annual deployment growth at least to 2020, then, based on these particular RETs, primarily via large-scale developments by large-scale developers will only serve to accumulate and intensify the systemic interactions of the potential constraints. This thesis shows that there are significant systemic interactions that already exist between the internal and external failures: internal>internal; external>external; and internal>external and vice versa. This creates systemic imbalances and unresolved tensions between the constraints. Critically, the current approach reduces the options available to addressing the systemic interactions of the internal and external failures.

(2) How would a UK response based on a systemic approach to renewable electricity technology deployment perform compared to the UK Government's current efforts to address the potential constraints?

The first research question has defined the limitations and the consequences of the current UK approach. In terms of performance, however, caution is required in extrapolating the benefits of a systemic approach; there is always the danger of poorly implemented policy and unintended consequences. Critically, policy is rarely designed on a blank slate. This question turns to the advantages of a systemic approach. These include:

(i) Permits an overview of the wider system

(ii) Leading from (i), the systemic approach permits the identification of the systemic interactions and the constraints to deployment for individual technologies in a novel way. This approach also permits their identification in a timely fashion (early)

(iii) The ability to make decisions at the systemic or system-wide level and take into account the systemic interactions of the potential constraints on the various renewable electricity technologies

(iv) Permits more targeted and focused reforms. As such, this should lead to the need for fewer interventions in comparison to the current UK approach

(v) Mitigates the risks to the fullest extent possible (knowing that such risks cannot be fully eliminated)

(vi) Helps to redefine the system in a more optimal and resilient way. The systemic approach offers a way to relieve the tensions inherent in the systemic interactions under the current approach

(3) *What could the systemic approach offer to policy makers?*

The systemic approach set out in this thesis offers a number of opportunities to policy makers. These include:

(i) The opportunity to interface across the system (or sector) rather than separate '*yes-no*' decisions to individual potential constraints to renewable electricity technology deployment capacity. As such, the systemic approach offers a mechanism by which to provide sectoral influence rather than separate decisions for different renewable technologies

(ii) Provides a deliberate tool in contrast to the current approach through individual decisions

(iii) Offers the potential to reduce the difficulties in matching the totalities of the project outcomes with the target

(iv) The systemic approach offers a more straightforward and pragmatic method of policy implementation in order to remedy the problems of the current approach. Critically, the current approach to addressing the internal and external failures reduces the options available to government to deal with the constraints. In other words, it offers policy makers an alternative route from attempting to pay or control the required increases in deployment necessary to meet the 2020 RES-E sectoral target and any future targets beyond 2020. The systemic approach, then, offers more control. In addition, adopting this approach makes subsequent steps to solving problems more predictable.

In other words, the systemic approach permits government to connect the dots in addressing potential constraints to deployment. With regard to the opening quote of the discussion between Alice and the Red Queen, the alternative is quite stark: continuation of the current business-as-usual UK approach will result in the government – like the Queen, having to run at least *twice as fast* in order to attempt to address the internal and external failures on a non-systemic basis. Even then, this will likely be insufficient. And ultimately, there is a limit to how long the renewable energy sector can hold its breath.

10.3 Original contribution to knowledge

This thesis provides an original contribution to the existing body of knowledge in four distinct ways: advancing current knowledge; methodology; an enhanced understanding of the research issue; and policy evaluation.

First of all, this thesis makes an original contribution to knowledge by advancing current knowledge and understanding of both the constraints to large-scale renewable electricity technology deployment in the UK and the way in which government approaches addressing these constraints. This has been done by providing a rich set of new and up-to-date data analysing the internal and external failures, including the type, design and operation of the existing subsidy mechanism, planning, electricity network (grid), public participation and engagement and policy risk (chapters seven and eight). Further, this thesis presents an in-depth, detailed analysis of the RO mechanism over a ten year period in terms of the actual deployment trends of the individual large-scale renewable electricity technologies (chapter six). In particular, this data set is based on the contextual investigation and analysis presented in chapters four and five of the thesis. One of the key contributions of this data set is that it can be used to evaluate the current UK approach to addressing constraints either individually (the current approach) or systemically (the systemic approach). As such, it both identifies and offers solutions on the impact of these constraints for a number of key large-scale renewable electricity technologies.

Second, this thesis makes an original contributes to an understanding of the research issue by demonstrating the evolution of the problem. Efforts to address the constraints to large-scale renewable electricity technology deployment is a more sophisticated target driven problem than previously evidenced under the Non-Fossil Fuel Obligation and, to a large extent, under the non-reformed Renewables Obligation. A comparison of the literature review (chapter two) in conjunction with Part III of the thesis (chapters seven, eight and nine) reveals that the approach to addressing constraints faces significantly more systemic problems than under the previous two mechanisms. Further, this highlights the need to adopt an alternative approach to addressing constraints as argued in this thesis.

Third, this thesis makes an original contribution to the area of policy evaluation by developing a novel way to evaluate the current UK approach to addressing potential constraints to large-scale renewable electricity technology deployment. In addition to highlighting short-comings in the current approach, this thesis provides an alternative option to policy makers based on the systemic approach (chapter ten). In contrast to the current approach which necessarily involves a number of trade-offs in attempts to seek solutions to individual constraints, the systemic approach does not require this, based as it is on a holistic or systemic approach. In other words, the systemic approach permits government to connect the dots in addressing the internal and external failures to deployment.

Finally, this thesis makes an original contribution to knowledge by developing and demonstrating the use of the systemic approach methodology based on the internal and external failures method to a novel topic: evaluating the UK government approach to addressing potential constraints to large-scale renewable electricity technology deployment. By showing the gap in extant research and modelling, the systemic approach builds on previous analysis and evaluation to reveal the existence of significant systemic interactions between the internal and external failures (internal>internal, external>external; and internal>external and vice versa) and a number of feedbacks between the constraints. The scope, application and limitation of the systemic approach are set out in chapter two of the thesis.

10.4 Future research work

There are a number of potential avenues for future research work deriving from this thesis. Whether or not the systemic approach is adopted in attempting to address the potential constraints to renewable deployment, this thesis has identified and offered tentative solutions to a range of constraints to large-scale renewable electricity deployment in the UK. These include the type and design of the existing subsidy mechanism, planning, electricity network, public participation and engagement and policy risk. By providing a rich set of new data on the impact of these constraints for a number of key RETs, this thesis offers researchers, policy makers and developers the opportunity to build on the research presented here.

However, it is the explicit hope of this thesis that the systemic approach to renewable electricity technology deployment will be adopted in due course. By highlighting the interactions of the potential constraints – the internal and external failures – the use of the systemic approach can be viewed as a foundation for further research work to build on. In order to correctly implement a systemic approach, extensive research work would be critical prior to implementation. An important question for the implementation of a systemic approach to addressing deployment constraints is: What would a systemic approach look like in terms of policy, legislation and regulation? This also leads on to the tentative examination of what a sustainable energy system should look like (see chapter one): What type of system is ultimately envisaged and how will it be obtained?

In particular, this thesis effectively questions the governance of the on-going experiment towards transitioning the UK energy system onto a low carbon/sustainable basis, with a current focus on the significant deployment of renewable energy technologies. This is particularly with regard to defining expectations, the granting of power and verifying performance. This is another potential avenue for future research work.

The systemic approach can also be utilised in additional 'novel' areas, including other countries that operate other types of subsidy mechanism alongside different policy, legislative and regulatory structure governing planning, grid access and public participation and engagement. This would offer the potential for a deeper understanding of alternative approaches to addressing the constraints to large-scale renewable deployment. The proposed CfD FIT is another important avenue. Anticipated to ultimately replace the Renewables Obligation, a systemic analysis of this novel mechanism is critical in attempts to understand how this untested mechanism will perform.

References

Carroll, L. 2000. *Alice's Adventures in Wonderland and Through the Looking Glass*. Signet Classics.